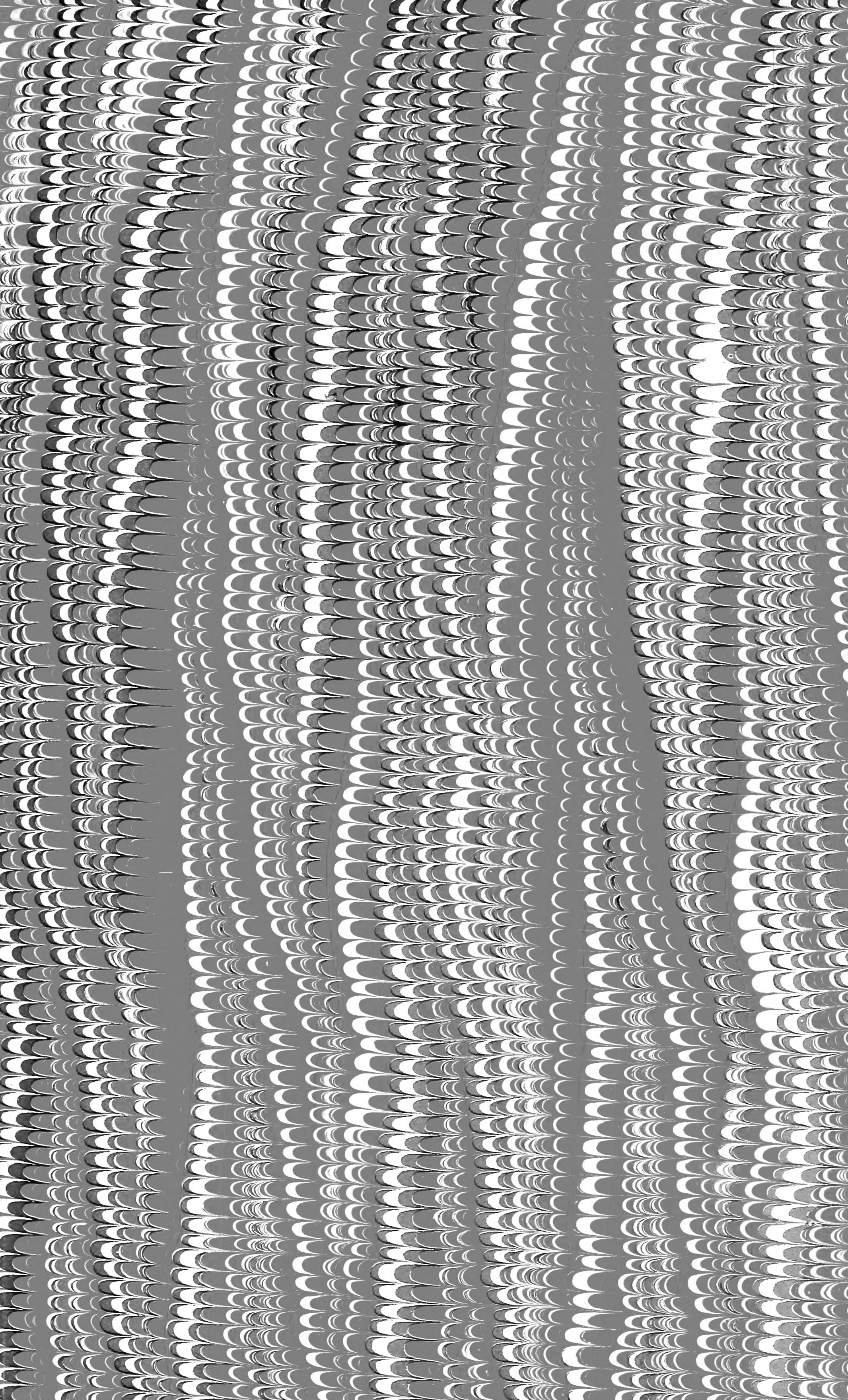

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JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOLUME 29, 1939

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ERRATA

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Page 142, line 23: For "dm" read "m."

Page 142, line 26: For "femineae" read "feminei."

Page 368, line 9, and in odd running heads throughout this paper: for "Kempten" read "Kempton."

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JOURNAL
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VOL. 29 JANUARY 15, 1939 No. 1

ICHTHYOLOGY.—*Salmon psychology.*[1] HENRY B. WARD, University of Illinois. (Communicated by CHARLES E. CHAMBLISS.)

Many years ago I became interested in the salmon and its remarkable life history. Good fortune brought me in personal contact with that great student of American fishes, David Starr Jordan, whose work on the Pacific salmon is well known. His discussions further stimulated my interest and I was able to enter on a series of field studies which has extended over more than 25 years. This work has been intensive rather than extensive and has taken a different direction from that of most of those who have been active in this field hitherto. From the start it has been rather strictly limited in that it was confined primarily to a single species of Pacific salmon, the sockeye or red salmon (*Oncorhynchus nerka*), and to that part of its life cycle spent in fresh water. I have been able to carry on this study at several widely separated places and incidentally to accumulate also scattered information concerning related species and genera which has afforded a valuable check on my own more extended observations of the red salmon.

Desiring to secure the most intimate contact possible with the species, I have spent the summer months following the adults from river mouth to spawning ground, endeavoring to determine just what they did and why under varying conditions of stream, climate, and weather. The tales and interpretations of tourists, natives, fishermen, and Indians were welcomed and subjected to impartial scrutiny in the task of sifting some truth from the mass of error and fancy that always pervades popular accounts of animal life. This combination of personal observations with explanations of others has in the course of time given an intimate knowledge of the fish in its environment sufficient to justify calling this address a study of salmon psychology. It is presented with full recognition of its incompleteness and imperfections, as a basis for directing attention to a somewhat neglected aspect of the study of the salmon.

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[1] Address delivered before the Washington Academy of Sciences, December 17, 1936. Received November 29, 1938.

Extensive studies on various types of animals have shown the existence of internal or functional influences and also of external or environmental influences as controlling or directing factors in animal activities. Internal influences are undoubtedly as real and as powerful in fish as in other types of animal life. They are however not discussed here. The purpose of my early studies has been to ascertain how far and in what way the activities of the Pacific salmon in fresh water are determined or modified by external factors. To do this it was necessary to collect by careful and extended study a considerable volume of facts and then to seek to correlate those facts with environmental conditions and the life of the fish. It seems probable that some internal or functional urge impels the adult salmon to start on its migration to the distant spawning grounds, but its exact course will be determined by series of environmental influences which at successive points condition its movements and thus determine its path. Unfortunately past observations on the fish have often been discontinuous or unrelated, and interpretations too largely anthropocentric.

The interpretation of animal activities from the standpoint of human procedure leads into serious misunderstandings. These are most apparent as one departs widely from those types of animal life which most clearly resemble man in structure and development. Nowhere is the error more frequent and more serious than in the treatment of the activities of fish. Even at the first laboratory studies on the structure of fish every student is confronted with the special development of the central nervous machinery, with the absence of the cerebrum, or fore brain, and the magnitude of the olfactory lobes. The student is impressed by the radical difference between the set-up of this system and that of man and the higher vertebrates. From it one may rightly infer that these differences indicate a basis for behavior of significantly different type. A correct knowledge of their habits also and of the underlying basis for their action in particular cases is of primary importance not only in seeking to explain the biological problems in the life history but equally in determining laws for the protection of the fish and proper methods of fish culture to increase numbers and provide against an excessive draft on the fish population in man's search for sport and food.

The study of responses to external stimuli must be made with definite precautions always in mind. First the environment is complex and one may find on analysis that the observed reaction may be due to any one of several stimuli. By extended observation or by experiment these stimuli may be separated or their particular influence be measured. Second, different species or varieties of animals even though closely related act differently under some apparently identical conditions. Accordingly the first step towards the solution of the problem must be taken along the path of determining how one sort of salmon reacts under given conditions. It is not difficult to see in certain cases how confusion has arisen because of failure to observe these precautions.

In the interpretation of salmon activities, a multitude of influences may appear in a particular choice. One must not expect to find a single factor determining what may appear to be superficially a single choice, and the determination of the route chosen by a salmon may depend at one point upon one and at a second place upon another environmental condition. In general, the salmon running in a given stream and at a set time all make the same choice, following a route in the river system often apparently erratic and without evident reason for the preferences shown. However, the path taken by a salmon run is consistently uniform year after year and spawning grounds in a given river system are limited in number and location.

The number of elements which might possibly be involved in the choice of the route is large enough to make the basis for the series of choices difficult to determine, and some earlier observers have felt themselves forced to adopt a mystical explanation. However difficult it may be to solve the problem, the scientist is not justified in accepting this solution. All the experiments with these fish under controlled conditions and all observations of fish in nature show a definiteness of choice which may reasonably be considered to have a factual basis. The problem of the student is to determine this basis in individual cases and by extended observations to ascertain how widely similar conditions determine the same reaction.

The salmon ranks rightly as the most famous of all fish. Its life story manifests a complexity by virtue of its migration from the sea, which is the home in the active growing life period, to fresh water for the discharge of its reproductive functions. Some confusion has been introduced into the story of the salmon as told by different narrators through the combination of features from the life histories of different species of this fish. In this address attention will be directed chiefly to a single species of Pacific salmon, the sockeye or red salmon, in the effort to analyze and determine accurately the response of that fish to the stimuli acting upon it in the changing environments encountered. The life in the ocean is for the most part unknown. The full grown fish appear regularly at the surface of the sea near some river mouth at a given season, enter fresh water streams, ascend to spawning grounds in the higher reaches, and, after discharging this function, all die. The eggs spend a winter in the gravel and the young which hatch in the spring descend gradually to the sea and there disappear, to return after a period as full-grown adults. The young sockeye does not start its journey down stream usually until the second or rarely the third spring.

Following the activities of an adult salmon in this migratory period of existence, one notes first that from the moment of entering the stream it is consistently fighting the current, always moving upward toward its goal. This response to the current stimulus contrasts positively with that of the young on the way to the sea; not swimming actively but drifting, feeding and playing, they float somewhat leisurely down the stream to salt water. While most young salmon start promptly down stream, the sockeye regularly does delay one year or more in a lake.

The adult salmon insistently pursue their course upstream, striving at rapids and falls to surmount these difficulties, and, despite unsuccessful attempts, persist in their efforts until they make their way into the higher levels or are exhausted and die. The erection of a barrier across the stream holds them at such a point, striving day and night to find a way upstream, but never turning back to seek a pathway in some other waters. When exhausted in their efforts to pass the barrier, they may drop back into a quiet, deep pool to rest before renewing their efforts. This may carry them back some distance, perhaps past a fork in the stream. Foerster records that on the Vedder River sockeye once started up the wrong stream at the fork when returning from such a rest. However, they proceeded only a short distance and finally returned to the fork whereupon they turned into the right branch, ascending to the barrier and resumed their efforts to find a way past it.

Incidentally, observations on salmon at barriers and in their efforts to ascend rapids or jump the falls, demonstrate very clearly that their course is not determined by sight, but by definite response to the movements of the water. They may even, when caught in a whirlpool, jump directly away from the fall. They may attempt to surmount the obstacle at some point where no passage is available, but by persistent effort or delaying at times for changes of water level, they succeed at places where, to the observer, success appears impossible on account of the height of the fall or the scanty flow of the stream.

On only one occasion have I seen sockeye during an upstream migration turn about and definitely swim down stream. In this instance closing the gates at a dam higher up on the stream brought about a sudden drop in water level. Then the salmon caught in a rapids became visibly alarmed by the change in water level, turned about and darted down stream until they reached a deep pool. Once in deeper water their excitement subsided; they began to mill around and when an adequate current was found started once more on the upstream journey.

When a stream is swollen to an unusual extent the movement of an upstream migration may be temporarily suspended. Thus extreme fluctuations of water level either up or down, modify mechanically the response to the current stimulus but even before the normal water level is fully restored the adult salmon start again the active dash upstream.

When the current proves too powerful to be conquered, the salmon do not go back to try another tributary and seek a new spawning ground or find an easier approach to the headwaters. They fight the stream until they perish and the run is destroyed. This was the story of the sockeye at Hell's Gate on the Fraser River.

If by drought or some human interference the river flow is cut off, they linger in pools waiting for the water to come again. If it does, they start up once more. If it does not, they perish from disease. But they never turn back!

As the adult sockeye, struggling vigorously and constantly against the current, swims up stream toward some spawning grounds, its route is so definitely limited that it has only two occasions for exercising a choice that will determine its pathway and its ultimate destination. First, whenever it reaches a junction, it might follow either water route offered. Second, it must sometime bring its journey to an end and choose a spawning ground.

The pattern of a stream system is complex, even though it be only a system of moderate size like that of the Skagit River in the State of Washington. Of the numerous possible tributaries into which the sockeye might conceivably go and of the many lakes and spawning grounds which might be selected, only a very few are actually visited. Furthermore the selection is the same year after year, which some observers have explained on the ground of an instinct; let us consider briefly the result of studies at such stream junctions. Earlier investigators spent some time in testing physical conditions at many junctions. They found that the sockeye did not choose consistently the larger stream, the more rapid current, the clearer water, or the reverse. In other words the choice was not determined by volume, velocity, turbidity or any other physical factor which they observed.

After having repeated these older observations without securing any different results, I noticed that in the earlier records statements regarding temperatures were vague, being entered in the record as "water warmer," or even only "warmer." Previous studies on fresh water bodies had involved careful serial observations on temperature and I was aware of the frequent contrast between conditions in air and in water. I began to take temperature records of lakes and stream during the sockeye migrations. Records were made of frequent observations at stream junctions and in spawning areas. Data were secured under all conditions of season, sunshine, wind, light, cloud, stream velocity and volume, melting snow and ice, and other factors that might possibly determine locally in any degree the relative condition of the aquatic environment during, before and after the sockeye run in certain streams.

Before proceeding to discuss examples of temperature influence, let me emphasize the fact that temperature limits are not absolute, nor can they be expressed in figures. There is nothing mathematical in the situation. It is however a very genuine relation. As in many other animals the sockeye recognizes a preferred zone of temperature and doubtless senses optimum, maximum and minimum levels although studies have not progressed far enough to assign even general numerical values to these levels. Furthermore the sockeye in one river do not react favorably to the same temperatures as those which are found in some other river. In general the sockeye in Alaskan rivers are acclimatized to a set of lower temperature levels than those in a Washington State river. Too few rivers have been studied to establish the conditions in many salmon streams or to justify attempts at generalization. Only brief reference can be made here to instances which with others are fully discussed elsewhere.

My own observations have shown definitely that in a considerable series of cases where the branches of a stream differ in water temperature, the salmon universally chooses the one which has the lower temperature. This is in keeping with a long accepted general belief that not only the salmon, but other fish belonging to the same family, are fond of the colder waters. In some cases the migrating salmon show equal definiteness of choice at junctions where no appreciable or constant difference in the temperature of the two streams could be demonstrated. Such a choice is evidently conditioned by some yet undetermined factor. Thus far no instance has been found in which the migrating salmon at a stream junction have chosen the branch exhibiting at the time of choice a higher temperature than the branch which was not followed; but this statement itself is conditioned by another factor, namely, the quality of the water in question.

Migrating salmon have been observed to pass by without hesitation a tributary, branch, or side stream in which the character of the water was well indicated by its name of Sulphur Creek. A change in the course of the headwaters of Sulphur Creek which eliminated the objectionable feature and left the water clear and cold resulted in diverting salmon from the ancient course into the modified waters of this creek, as it was now pure and lower in temperature than the stream the salmon left. Undoubtedly, other factors than water quality do determine the precise choice of migrating fish at stream intersections.

The second opportunity for choice in the fresh water life of the salmon is afforded at the end of this journey upstream. For the sockeye this upstream journey usually stops in a lake in or near which are the spawning grounds. In the deeper water of the lake they rest, it may be for some weeks, until they are ripe and the time for spawning is reached. To reach this point the sockeye sometimes without stopping pass through a lake in the course of the stream. I have not been able to study conditions in such lakes. The lake in which they finally come to rest offers cool deep water as a resting place during the ripening of the fish. When the sex cells are close to maturity the fish rise out of the deep water and find gravel beds for spawning. These are at points along the lake shore, in the inflowing stream just above the lake or in the outflowing stream near the outlet. Here, again, it is sometimes evident at least, that a selection is made of areas in which the seepage of ground water or the inflow from a colder tributary affords an attractive temperature and at the same time the type of gravel bottom selected for the nest of the fish. In northern latitudes this is an interesting and important choice, since by it the salmon nests are made in seepage waters which do not entirely freeze during the winter, but are kept open by the flow of the ground water. When the fish restrained by an artificial barrier in the stream are prevented from reaching spawning grounds and forced through advancing ripening to release eggs and milt in unsuitable areas, these consistently perish in the long cold winter of extreme northern locations, but eggs of the same fish, normally deposited in higher reaches of the same stream not less subject to adverse atmospheric conditions, survive and yield a new brood in the spring.

The definiteness with which the salmon responds to the temperature stimulus in finding spawning places is strikingly illustrated in observations I made in Clear Creek, a tributary of the Copper River in Alaska. The fish under observation were red salmon which, as Jordan, Gilbert, and others state of this species, "always spawn in a lake." These observations I have recorded in full in an earlier paper. At the time of my visit salmon were found entering the stream from the Copper River, scooping out nests and spawning along the banks of the creek. Clear Creek does not now have any lake at any place in its course, nor has it any indication of having had a lake at any earlier period. At its junction with the river Clear Creek at the time of my visit was two degrees Fahrenheit lower than the river. The salmon turned into it promptly; the region in which they were spawning was much colder than the stream further up; it was also an area in which a good supply of cold ground water was welling up into the stream through a sand and gravel bottom. No salmon were going upstream beyond this point; neither salmon nor evidence of previous spawning was found beyond that point. The fish fail here to spawn in a lake, the general habit of the species, but they conform definitely in the response to the temperature stimulus given elsewhere.

But other environmental conditions probably aid the salmon in finding its way to the spawning grounds. The sockeye were found to be sensitive in some instances to the quality of the water, as in the case of Sulphur Creek previously mentioned. At another place they refused to enter a trap built of new green boards, though indifferent to a similar adjacent trap of seasoned concrete. Other observations also serve to show the existence of ability to discriminate on the basis of chemical sense (taste, smell).

Sight plays a secondary role, in general, in the activities of fish. The eye is conspicuously rounded and myopic. While this is partial compensation for the density of the medium in which fish live, the eyes are not accurate in interpreting objects. The lures of the fisherman when effectively handled lead the fish to grasp at them or jump for them on the basis of position on the surface, movement, form, or color of a character known in other more desirable objects. The lure creates a transient impression by some feature that produces a particular effect and not by its actual resemblance to the object sought by the fish.

In the choice of the migration route and in the success of the sockeye's journey, sight plays an exceedingly minor part. At a rapids where the salmon seeks by jumping to attain a higher level, it often jumps into a closed pool, onto a bare rock surface, or into a tangle of shore plants from which it may extricate itself by aimless floundering about, or where it may become trapped and perish. It will jump endlessly at a fence erected to barricade the stream or swim back and forth incessantly seeking an opening large enough for its exit when no jump can top the fence and no search can find an opening.

The migration route cannot even be generally directed by memory or persistence of past images. To be sure in many cases, perhaps in most, the adult fish ascends the same stream which in early life it descended to the sea. But as already noted the young fish going downstream plays along near the shore; the adult swims strenuously in deeper water on its way up the same river. The two pathways are separated by a distance greater than the range of sight. Even if floods have not intervened and produced radical alterations, the river channel and banks have changed every season and with that all the features with which the young fish had come in contact. Whatever aids sense perception gives in determining the way upstream, they are not furnished by the organs of sight.

The influence of light on migration movements of the sockeye is important to consider. In my observations the adults were not found to continue the upstream migration during hours of complete darkness but to rest in deeper holes or in eddies. With the coming of dawn they began to move upstream and in a brief time were vigorously combatting the current and jumping at falls. Later in the morning this activity diminished and ceased on sunlit days, though in cloudy weather it was manifested intermittently during the midday hours. As the sun declined the sockeye again became active and continued through the twilight hours. The period of activity seemed to be limited to the time of diffused illumination and to terminate when the direct rays of the sun were no longer totally reflected from the surface of the water. When in the late afternoon conditions were changed again, then the fish were once more active until the twilight period came to an end.

Some situations are difficult to analyze. Thus, the effect of a heavy rain is seen clearly and very promptly and has been witnessed and recorded by many observers, both on the Atlantic and on the Pacific coast. During a spell of dry weather, which usually is also warm weather, salmon which are at the mouth of a river or have started up, loiter about in deeper pools and appear to have lost the desire to fight the stream. Even a moderate rise in the stream as the result of rain promptly arouses the activity of the fish and they shoot ahead vigorously. Here the stimulation may be due to volume, temperature, or quality of the water. The first-named cause seems least likely because salmon in nature frequently leave a stream of large volume to continue the migration in one much smaller. But salmon like cooler waters such as one finds in streams after a rainstorm; then also they have fresher waters and changed relations of O_2 and CO_2 tension. This situation is only apparently modified in Alaska where warm sunny weather means rapid melting of ice and snow on nearby mountains. Thereupon the streams carry promptly a daily flood of cold water and the sockeye go up eagerly. This evidences that they also are keen at this period of life to follow the taste of fresh river water. Perhaps both stimuli here favor rapid action. In the complex environment of nature many other factors still remain to be investigated before it is possible to complete the list of the responses which the adult salmon makes to the conditions met during the migration to the spawning grounds.

Concerning the young salmon on its way to the sea, little need be said. There is no choice except to go or not to go, and the movements of the young fish in the downstream direction are slow and apparently hesitating. Young sockeye do not leave the lake in or near which they were hatched until the second spring or even later. As they proceed downstream they feed and play in the small eddies along the shore, dropping occasionally from one level to another as if disinclined to make the venture. But they go over the spillway of a dam involving a descent of 240 feet in just the same way that they drop down a 6-inch step in the rapids. Their vacillating movements contrast sharply with the vigorous striving of the adult to make the ascent of the river. In lakes or reservoirs met on the journey the young keep near the shore; when affected by rising temperature of surface waters they descend into deeper water to find a cooler environment and become trapped by the surface stratum of warmer water which blankets the lake and cuts off access to the outflowing stream. Here in the lake or reservoir they remain "land-locked," cut off from further downstream migration since that can only be carried out if they desert the cool, deeper water levels to enter a warmer current. And that they will not do. So here again is seen the response of the salmon to a temperature stimulus. Those young sockeye which find their way open and reach the sea, disappear in the deeper waters, and thereby pass out of the freshwater region to which this account was to be limited.

These observations show only imperfectly the influences which direct the migration of the adult salmon in the period of its freshwater existence. Further determination of factors or of the extent to which those illustrated are operative, must await further studies, but from these one may conclude that at least one current belief is not tenable. The fisherman stoutly avers that the adult salmon returns to the very gravels in which it was spawned and hatched, and this view, designated as the "parent stream theory," is widely held by others. But after all, this is no explanation in any sense; it is at most only a convenient expression to conceal lack of knowledge concerning the real situation. At best it assumes the inheritance of a vague, indeterminable influence which does just the right thing at just the correct time to enable the young salmon to find their way from the river mouth to some suitable feeding grounds in the ocean and when the time of maturity is near at hand to retrace their steps to a place known to be fitting for spawning because these particular fish were spawned and started life at that point. A view so indefinite, so loaded with assumptions and so mystical in character, can hardly serve the purposes of scientific investigation however convenient and appealing it may be.

Some of the difficulties in accepting this view deserve at least brief mention here. The correctness of the assumption that the salmon return to a parent stream is at least still open to question. Time does not permit an extended discussion here of the proofs thus far offered. It is my intention to present at a later date a fuller analysis of the various observations and experiments which have been put on record. In my opinion they are not conclusive. While they show that some salmon do conform to the assumption, it is equally certain I think, that all do not. The positive evidence secured has been unduly emphasized and the defects in the proof overlooked. The number of salmon that have been marked or tagged in numerous experiments is very large; the percentage of such that have been recaptured is too small to justify the claim that the record is "conclusive evidence." Let me illustrate what I mean.

A serious-minded student stands at the entrance of a great industrial plant and watches 10,000 employees pour out and swarm down the road which leads to the city. By skill he marks 500 of these and his assistant located at the entrance to an amusement resort on the other side of the metropolis recognizes 10 of the marked men and women entering the resort some hours later. He thinks there were more who passed unnoticed in the crush at the gates he was watching. No one else has noticed any of the marked workers going anywhere else. What conclusion may be reached properly from such data? In their major factors the two cases are strikingly similar and also equally alike in proving nothing about the habits of fish or men. The same misuse of results from a type of random sampling led a prominent news service into ludicrous and serious error in a political campaign not many years ago.

Apparently no one has yet given attention to the non-conforming element. It is hardly satisfactory to dismiss the case with the statement that sometimes an erratic or abnormal salmon may turn up in the wrong place. The number of such strays is too large to be thus summarily discarded and given no further consideration. Certainly an answer must be sought to some questions which suggest themselves. How large is the part which does not return? Where does this fraction go? What influences that fraction, be it large or small, to go to a new spawning ground and do violence to the inborn, mystical compulsion which the parent stream theory assumes? These questions are difficult to answer. I have felt that some light might be thrown upon the situation by study of the fish in a simple environment, and that is during the part of the life cycle spent in fresh water.

From evidence already published and also outlined in this paper, I feel that there is more reason to believe that in its progress upstream the adult follows a highway through the waters which is marked out from point to point by signs as definite as those which determine for us our course along a road. The highway signs that mark the way through the waters are indicated by temperature, quality of the water, or other physical and chemical features that yield responses as definite as those which we find the fish manifesting under controlled conditions in experimental tanks. The stream which the salmon ascends is not necessarily a home stream, nor is the course of the fish determined by previous knowledge of these waters. The adult seeking the spawning grounds goes upward by constraint along a fixed route and the young wander downstream following necessarily the same course to reach inevitably the waters of the ocean, in which they find conditions for life and growth to maturity.

No assumed mystical impulse makes them go back to a specific place because of their relation to that at the start of their existence. They do, perhaps usually, return to that place because like their ancestors they react in a specific way to the stimuli they encounter on the journey. But they do this only so long as the conditions they meet on the journey remain unchanged. To characterize the situation as due to a parent stream theory is to adopt an empyrical conclusion with all the errors and limitations of empyrical findings. It is to abandon the search for a scientific basis and to lose the greater power over changing conditions which knowledge of controlling influences will give. If the salmon have been shifted to a new environment or if by any disturbing influences the environmental conditions of the old route have been changed, they go to some other place, a new goal determined by the newly created conditions which they meet. To those new conditions they react in the manner determined by their nerve pattern and not by the ancestral relation to any geographic locality.

No one should lose sight of the fact that even in our rivers and on our coasts natural conditions are changing and these changes give opportunity for distribution of a species into new areas as well as for the origin of possible new species. Some efforts have been made already to explain on such a basis the origin of the Pacific salmon and their wide distribution along the coastal areas of the northern Pacific. A recent species, geologically speaking, its origin may be associated with the period of continental glaciation when it spawned along the shore at the foot of the glaciers. As these ice fields slowly receded it followed up the resulting water courses to find its spawning grounds near the source of the stimulating cold freshwater run-off from the glaciers.

Different species of Pacific salmon do not respond in the same manner to the same stimuli. One conspicuous instance of this has been mentioned: the sockeye young usually tarry over one winter in a lake. Other species of Pacific salmon go more or less promptly down the river from the place they were hatched into salt water and disappear. In variable periods the different species reappear as full grown fish and start upon the freshwater period of their existence. It would be interesting to follow the precise story of these other species of Pacific and Atlantic salmon on the coasts and in the streams of North America. Accounts by older and more recent students of the problem give many details of these stories. The accounts manifest general similarity though differing in details just as the structure of all these forms exhibits a general likeness despite the particular differences also recorded. In both series are to be found evidences of the past that deserve closer attention.

Finally, to make the story complete, the record of the sockeye's life in the ocean must be studied from the same point of view as that taken in the account of its freshwater existence which has just been reviewed. One can hardly doubt that similar environmental stimuli affect it; namely, current, temperature, quality of water, etc. But how does it react? Where do these controlling influences lead it and what brings it, after a period of active growth, back to the shore?

What leads it to enter some river and seek a spawning ground? Surely, not a blind instinct or some inscrutable impulse. In the sea environmental conditions are more variable and change violently and suddenly. Periodically storms modify currents; schools of fish are broken up and scattered widely. Even under generally favorable conditions only 20 or rarely 40% of tagged fish have made the short journey to the places where keen-eyed watchers were waiting for them. Why did this marvelous instinct fail them? Is it not more reasonable to suppose that in shifting waters some were brought into new environmental conditions. In these they responded naturally to the same stimuli that had led their ancestors for unnumbered generations. But those stimuli under the changed conditions lead them to a new goal. Complex as the ocean is, one finds there the same environmental stimuli, mechanical, physical, or chemical, that are in fresh water, and these guide the salmon to some suitable stream for the last phase in its life cycle.

The address was illustrated by a series of lantern slides and figures made from photographs of conditions in nature taken in the course of studies in the field, and by maps of the regions covered. Some further detailed explanations were presented in connection with slides and maps as shown.

PALEONTOLOGY.—*A fossil catfish* (Felichthys stauroforus) *from the Maryland Miocene.*[1] W. GARDNER LYNN and A. M. MELLAND, Johns Hopkins University. (Communicated by C. LEWIS GAZIN.)

A well-preserved skull taken from Zone 12 of the Calvert Formation of the Miocene about three miles south of Plum Point, Maryland, proves to be that of a marine catfish congeneric with the Recent gaff-topsail fish, *Felichthys felis.* This specimen provides the first record of a siluroid from these deposits and indeed appears to be the only complete skull of a fossil marine catfish yet known from North America.

The catfishes (Order Nematognathi) fall into some twenty-five families, most of the members of which inhabit freshwater streams and lakes. However, one large family, the Ariidae, contains about forty-five estuarine and marine genera, which are widely distributed in tropical and sub-tropical regions. The Nematognathi are represented but scantily in fossil records for, although a considerable number of fossil species have been described, the remains upon which most of them are based are too fragmentary to permit of any accurate de-

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[1] Received November 18, 1938.

termination of their relations. The greater number of the fossil forms are known from the otoliths alone; others are represented by isolated fin spines or vertebrae; only a few well-preserved crania have ever been found.

In Europe, fossil members of the Nematognathi are known from deposits ranging from Lower Eocene to Pliocene and have been recorded from England, France, Belgium, Germany, Hungary, and Italy. Fossil catfishes have also been reported from the Middle Eocene of Sumatra, from the Miocene of Brazil, and from the Miocene of India. The literature pertaining to these records is to be found in Woodward's "Catalogue of the Fossil Fishes in the British Museum" (1901) and has been adequately reviewed by Leriche (1901). It therefore need not be discussed at length here.

In North America, the group is very poorly represented. Hay (1929) lists only twelve species of catfishes which have been described from deposits of the North American continent. Five of these have been assigned to the Recent genus *Ameiurus*, a freshwater group belonging to the family Ameiuridae. Since these freshwater forms differ rather widely from the marine catfishes it is not necessary to discuss them in connection with the present specimen. The other seven species were all described by E. D. Cope who erected for them a new genus, *Rhineastes*. The remains upon which these species are based are extremely fragmentary, consisting of small portions of skull plates, isolated fin-spines and otoliths. Nevertheless, they are sufficiently complete to indicate clearly that the genus belongs among the sea-catfishes so it has been assigned to the family Ariidae by Jordan (1923). Pertinent information is given in the following list:

R. arcuatus Cope 1873. Mid. Eoc. (Bridger) Wyo. Type, U.S.N.M. No. 3985. Spine and fragments.
R. calvus Cope 1873. Mid. Eoc. (Bridger) Wyo. Type, U.S.N.M. No. 3980. Fragments of cranium, dorsal spine.
R. pectinatus Cope 1874. Mioc. (Florissant) Colo. Type, U.S.N.M. No. 4086. Head and anterior part of skeleton.
R. peltatus Cope 1872. Mid. Eoc. (Bridger) Wyo. Type, U.S.N.M. No. 3984. Occipital-parietal bone and dorsal spine.
R. radulus Cope 1873. Mid. Eoc. (Bridger) Wyo. Type, U.S.N.M. No. 4099. Fragments of skull.
R. rhaeas Cope 1891. Oligoc. (Assiniboia) Canada. Abdominal vertebra.
R. smithii Cope 1872. Mid. Eoc. (Bridger) Wyo. Type, U.S.N.M. No. 3977. Basi-occipital, vertebrae, pectoral spine and articular of mandible.

The type specimens of *R. rhaeas* are figured by Cope (1891) and those of all the other species have been figured by Cope (1884). Examination of these figures and of the types themselves reveals the reason for the great difficulty which has been encountered in attempting properly to diagnose the genus and as Eastman (1917) remarks, "How closely *Rhineastes*, from the Green River Eocene, agrees structurally with modern species of siluroids cannot be determined, as it is known only by fragmentary remains." In any case, as will be shown, the present specimen shows such well-marked affinities with the modern genus *Felichthys*, that we have no hesitation in referring it thereto.

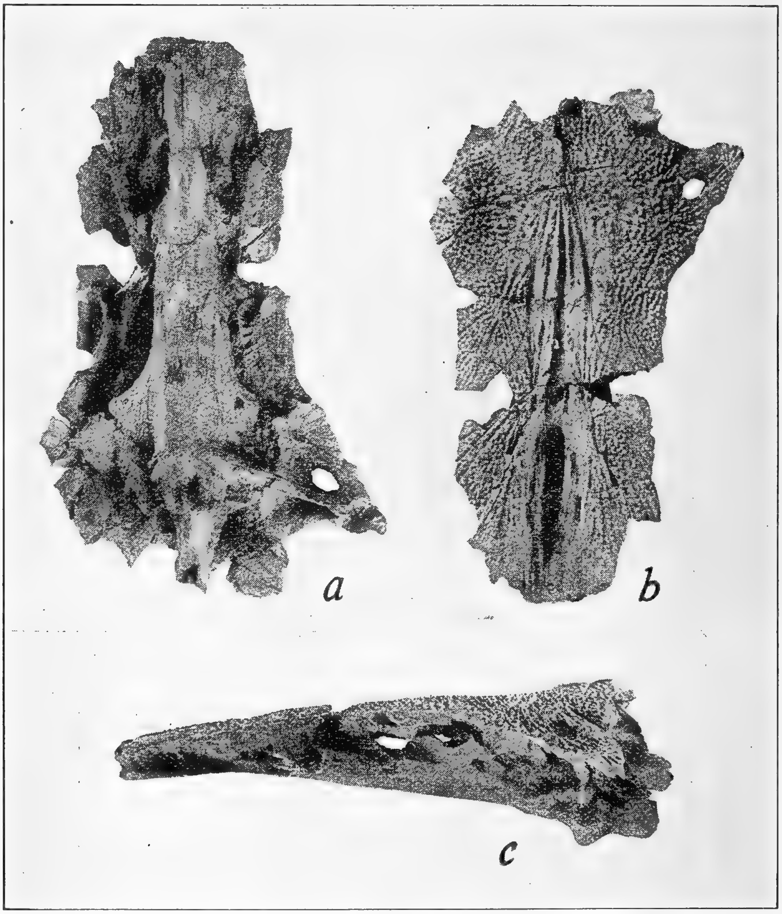

Fig. 1.—*Felichthys stauroforus*, n. sp. Skull, type specimen, U.S.N.M. No. 15746. *a*, ventral aspect. *b*, dorsal aspect. *c*, lateral aspect. All views ×½.

Felichthys stauroforus, sp. nov.

Type.—U.S.N.M. No. 15746. A nearly complete skull and the left utricular otolith from the same specimen.

Type locality.—Zone 12, Calvert formation of the Miocene, three miles south of Plum Point, Maryland.

Description of skull.—As may be seen from the figures (1a, 1b) the most important deficiency in this specimen is the absence of the most anterior skull bones; the ethmoid, prefrontals, premaxillae and vomer. The right post-temporal and the posterior portion of the supraoccipital have also been lost. All the other bones are practically intact and have suffered no noticeable distortion. The sutures of the dorsal surface are well-marked and reveal the outlines of the various plates to be as shown in figure 2. The frontals, which form the anterior part of the specimen as preserved, narrow posteriorly and are separated at their hinder extremities by the narrow anterior projection of the supraoccipital. Two frontal fontanelles are present; the anterior, elongate one measuring 32 mm. The sphenotics which contact the posterior lateral borders of the frontal are rather large and take part in the formation of the lateral edge of the skull. They are in relation with the frontals, the supraoccipital and the pterotics. Their lower surfaces bear prominent arched ridges bordering deep depressions, the points of attachment for the hyomandibular. The pterotics, which lie behind the sphenotics, articulate medially with the supraoccipital and posteriorly with paired bones which apparently represent the "scale bones" figured by Gregory (1933) in

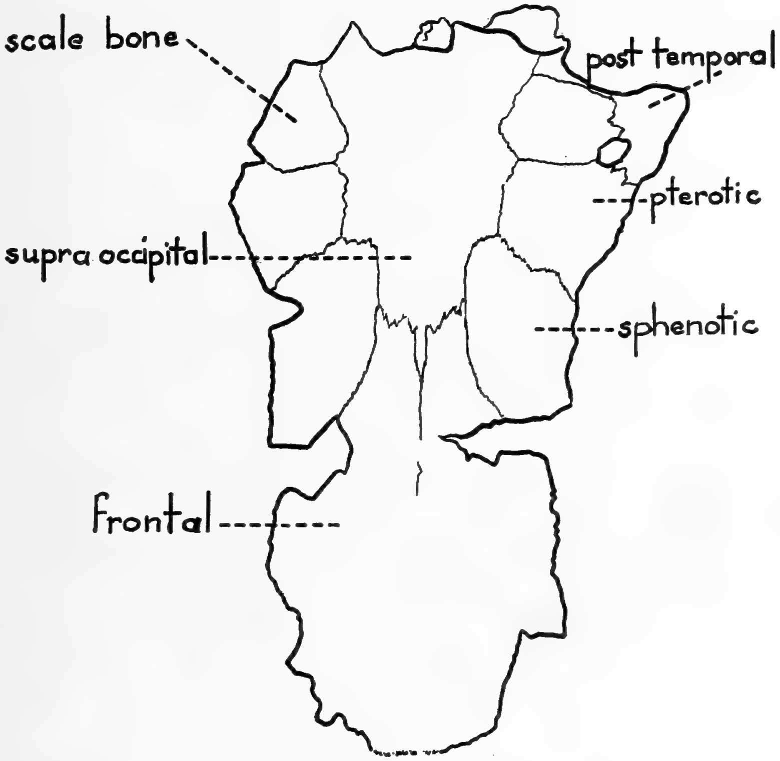

Fig. 2.—*Felichthys stauroforus*, n. sp. Dorsal aspect of skull showing outlines of bones. ×$\frac{3}{4}$.

Chrysichthys. Laterally the pterotic forms a part of the lateral border of the skull but, at its posterior lateral end, articulates by a blunt process with an anterior process of the post-temporal. Since the scale bone which lies behind the pterotic articulates similarly with a posterior process of the post-temporal, a foramen bordered by the pterotic, scale bone and post-temporal is formed in the posterior lateral portion of the skull. This foramen measures 9 mm by 5 mm. In the under side of the skull the post-temporal articulates by a long bar of bone with the basioccipital. The supraoccipital, which contacts all the bones above described except the post-temporal, has a thin anterior projection between the two frontals and its lateral margins are indented by a series of curves where the plate is united with the frontals, sphenotics, pterotics and scale bones. The hinder portion of the supraoccipital is missing but the bone evidently narrowed posteriorly. There is a prominent crest in the mid-line of the posterior half of this bone, but anterior to this is the beginning of the deep median depression in which lie the frontal fontanelles.

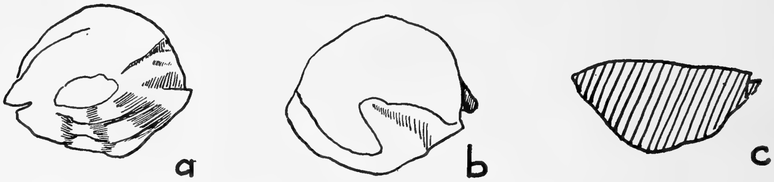

Fig. 3.—*Felichthys stauroforus,* n. sp. Left utricular otolith. *a,* inner surface. *b,* outer surface. *c,* diagrammatic section.

The dorsal surfaces of all the skull bones are ornamented with rounded projections which are arranged in definite rows, the individual projections in each row being connected by a low ridge. These rows of projections tend to radiate from the centers of the bones toward the edges. Crossing the scale bone, the pterotic and the sphenotic are rather ill-defined grooves which may indicate the courses of the lateral line canals.

On the under surface of the skull the sutures are ill-defined and slight crushing of the otic region on the left side makes exact description of the bones of this region difficult. The cruciform structure formed by the basioccipital and parasphenoid and the ventral processes of the post-temporals, which is a distinctive characteristic of the skull of the Ariidae and which has been most interestingly discussed and figured by Gudger (1925), is a striking feature in this specimen and suggests the specific name *stauroforus* (cross bearing). At the posterior end of the skull a portion of the mass of bone formed by coalescence of the centra of the anterior vertebrae is preserved. This is fused anteriorly with the basioccipital, the point of fusion being marked by a large, rounded ventral projection. Immediately anterior to this is a foramen leading into the centra of these vertebrae. The ventral process of the post-temporal articulates with the basioccipital just anterior to this foramen. Only that of the left side is preserved. The otic capsules, which house the large otoliths, lie laterally in this region. The deep depressions in the ventral sides of the sphenotics for attachment of the hyomandibular lie anteriorly to the otic capsules. In front of these the skull broadens to a fan-shaped mass, made up of the parasphenoid and the under sides of the frontals.

The skull, as preserved, has a maximum length of 139 mm and a maximum width of 84 mm. Since figure 2 is drawn to scale it is unnecessary to give complete measurements of the individual bones.

Description of otolith.—Since the otoliths of the fishes frequently furnish reliable diagnostic characters it seemed advisable to attempt to recover the otoliths in this specimen. A narrow break already present in the right wall of the cranium made it possible to clear away some of the matrix inside the brain case without injury to the skull. Fortunately the otoliths were found to be present and the left one was removed practically intact. The right otolith has been left within the skull.

In studying this otolith extensive use has been made of Frost's (1925) excellent descriptions and figures. The specimen is of large size (14 mm long and 12 mm high) and agrees with Frost's description of the utricular otoliths of the Ariidae in being conchoidal and biconvex. The inner surface (figure 3a) is rugose with a number of concentric ridges. A posterior process with a slight indentation is present but it has been damaged. The anterior process is rounded. The dorsal rim of otolith is rounded while the ventral rim is truncated posteriorly and indented slightly just behind one of the strong, radiating ridges. The outer surface (figure 3b) has a roughened band along the entire ventral rim with a broad, recurved projection just behind the middle. The rest of this surface represents the smooth sulcal area. The outer surface (figure 3c) is much less convex than the inner. Comparison of this otolith with Frost's figures for members of various families of the Nematognathi immediately confirms the identification of the present specimen as belonging to the Ariidae, for the otoliths in this family are easily distinguishable from those of other siluroids by their large size, their form and the shape and location of the sulcal area. Moreover, among the species considered by Frost the otoliths of *Felichthys marinus* are definitely closest to the present specimen.

The association of this fossil with the genus *Felichthys* on the basis of skull characters is thus confirmed by the structure of the otolith.

As has been pointed out, only a very few well-preserved skulls of fossil catfishes have ever been reported. One of these, however, that of *Bucklandium diluvii,* is especially noteworthy as being the earliest true siluroid known. This specimen from the London Clay (Lower Eocene) of Sheppey, was first figured by König (1825) who regarded it as representing a lizard. Morris (1843) later recognized its piscine nature, but it was not until 1889 that Woodward assigned it to the siluroids. Jordan (1923) places the genus *Bucklandium* in the family Bagridae. A skull from the Upper Eocene of Barton has been described and figured by Newton (1889) who refers it to the fossil species *Arius crassus,* a form previously known only from the otoliths. This specimen is sufficiently complete to be comparable with the skull described in this paper, from which it differs in the absence of the posterior frontal fontanelle, the absence of the post-temporal vacuity and the shape of the supraoccipital.

Ameiurus primaevus, described by Eastman (1917) is perhaps the best known of all the fossil catfishes, since it is represented by a nearly complete skeleton. The origin of this specimen is unknown, though the nature of the matrix indicates that it came from the Green River Eocene of Wyoming.

It is unfortunate that the relations of *Felichthys stauroforus* with the only other known fossil Ariidae from North America, those of the genus *Rhineastes,* cannot be ascertained. However, the fact that in *Rhineastes* the frontal fontanelle is completely closed, may be taken to indicate that the relationship is not close.

The present-day members of the genus *Felichthys* are predominantly subtropical in distribution. *Felichthys felis,* according to Gudger (1916) "ranges as far north as Cape Cod, but is especially common along the South Atlantic and Gulf coasts where it is abundant in brackish waters, for which it seems to have a predilection." Eigenmann and Eigenmann (1890) state that it is found along the Atlantic coast from Cape Cod to Rio de Janeiro. Maryland is thus included in the present range of the genus, but it appears to be most common further south. In view of this distribution of the modern representatives of the group, this record of *Felichthys* from the Maryland Miocene may be an addition to the gradually accumulating evidence, which has been recently discussed by Collins and Lynn (1936), that the temperatures in Maryland during the Miocene were somewhat higher than they are today.

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PALEONTOLOGY.—*Certain pleurotomariid gastropods from the Carboniferous of New Mexico and Texas.*[1] GEORGE H. GIRTY, U. S. Geological Survey.

I. TAOSIA, A NEW GENUS OF HIGH-SPIRED PLEUROTOMARIAS WITH COMMENTS ON TAOSIA COPEI WHITE

The genus *Taosia* is based on *Murchisonia copei* White of which the original specimens were found near Taos, New Mexico, hence the new name.

Taosia possesses a combination of characters not found in any pleurotomarioid shell known to me. Indeed, my ever-helpful and erudite friend, J. Brookes Knight, tells me that he had independently marked down *Murchisonia copei* as typifying a new genus though he has generously yielded me the privilege of describing it. The following characters should be noted:

The long, slender shape; the large number of volutions (possibly as many as 15); the shape of the whorl, which is angulated about midway so that the external surface is sharply differentiated into two zones; the overlap of the whorls to a line well below the carina so that the spire is flanged like a screw; the position of the slitband, midway in the upper zone instead of on the carina; the wide slitband and short slit; the shell composed of two layers; the solid axis without even a false umbilicus; the very tenuous inner lip; the all but complete absence of sculpture. This last statement contemplates a distinction between sculpture and configuration. The carina would come under the head of configuration; the two raised lines which form the boundaries of the slitband would be structural; the delicate lines of growth are not in any true sense sculpture, and the only feature under that head would be the single revolving line on the lower surface.

Taosia is very similar to *Goniasma* in configuration (for example figures 15 to 19), but aside from numerous less significant differences it is distinguished by the position of the slitband which in *Taosia* is situated above the carina midway on the upper surface of the volution, but in *Goniasma* is situated just below the carina on the lower surface. From *Lophospira* also *Taosia* is distinguished by the position of the slitband which is situated not on the carina but above it and it is likewise distinguished by its imperforate axis, by the absence of revolving lirae (on the type species at least) and by other characters.

Taosia copei, though it has never been cited since its original description in 1881, at least in descriptive literature, is not by any means a rare species. I have collected it myself at Taos where it was originally found; it is fairly common in the McCoy formation in Colorado from which specimens were sent to me by I. A. Keyte and it is rather abundant in rocks identified as the Magdalena limestone and exposed in the western foothills of the Frank-

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[1] Published by permission of the Director, Geological Survey, U. S. Department of the Interior. Received August 29, 1938.

lin Mountains north of El Paso. The specimens from the Franklin Mountains are not only abundant but in a better state of preservation than those that I have seen from the other localities. I have figured several of them to illustrate the genus and have based the subjoined comments on *Taosia copei* upon them. The rocks at Taos from which *T. copei* was described are, I believe, regarded as Magdalena limestone.

Toasia copei White Figs. 1–7

White's description which accurately covers the salient characters of *Taosia copei* may advantageously be quoted at this point, especially as the species has never appeared in descriptive literature since it was established in 1881.[2]

"Shell slender, apical angle 20° to 25°; full number of volutions apparently about fifteen, all strongly angulated, the angle being more or less distinctly carinated; carina not crenulate; angle situated nearer to the proximal than the distal border of the volutions; spiral band occupying the middle of the outer flattened side of the volutions, of moderate width, inconspicuous, and bordered on each of its sides by a raised line; the remainder of the outer surface of the volutions marked only by fine lines of growth; the proximal side of the last volution marked by one distinct revolving raised line near the carina."

"Length of adult shells from 25 to 30 millimeters."

T. copei is very abundant in my collections from the Franklin Mountains and many of the specimens are in an excellent state of preservation, though none has been observed that is not broken at the apical end and also at the aperture. Observations based on this material enable me to add some characters to those noted by White. His description allows the apical angle a variation of from 20 to 25 degrees; this is true of the common run of specimens but would hardly cover the extremes. The species attains a size considerably greater than that of the types. The final volution may have a diameter as great as 15 mm and an individual of that size is estimated to have been as long as 40 mm.

If specimens the size of the types consist of about 15 volutions, these larger specimens should probably be credited with about two more. The number given in the original description, however, seems to be excessive. The larger of the two types apparently comprises not more than 6 volutions; it is hardly conceivable that 9 volutions are lacking from the broken spire, and only a few volutions can be added at the proximal end if the length of a mature specimen is but 30 mm. Specimens in the present collection, for instance the one represented by figure 2, support the doubt expressed above. This specimen is very similar to the larger type, but is slightly less incomplete. Not more than half a volution is missing at the aperture where the shell has a diameter of 10 mm. The diameter at the broken apex is 2 mm and the actual length 24 mm. The number of volutions is 7. With an allowance for breakage the original length may be reckoned as 30 mm and with an allowance for the broken aperture the number of volutions except for

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[2] White, C. A. U. S. Geol. Survey West of the 100th Merid. **3** (suppl., Appendix): XXXI, pl. 3, figs. 10a, b. 1881.

those missing in the spire, may be reckoned as 8. It does not seem likely that 7 volutions are missing from the spire, or in other words that the shell, at a diameter of 2 mm, had accomplished 7 volutions.

The most conspicuous surface feature is of course the carina which on the final volution is situated somewhat below the middle but on the turns of the spire much below the middle. The screw-like shape of the spire is a notable feature of most specimens but the flange of the screw is unsymmetrical, short and strongly oblique on the lower side, long and more gently oblique on the upper. Some variation in shape is occasioned by variation in the direction and in the width of the narrow zone below the carina.

The upper part of the volution, from the carina to the suture above, is essentially flat or faintly concave; rarely faintly convex. It is traversed by two slender raised lines which divide it into three zones of approximately equal width though the upper zone is commonly somewhat wider than the others. The middle zone, which is of course the slit band, varies considerably in width and this entails a variation in the relative widths of all three zones. A third raised line occurs on the lower surface of the volutions. The zone contained between this line and the carina is about equal in width to the zones that occur on the upper surface, being about as wide as the upper one and somewhat wider than the two lower ones, but where the lowest of the three is especially wide, the two zones, one above and the other below the carina, are of equal width. This raised line or slender ridge on the lower side of the volution is apt to be a little stronger than the two that define the slitband, and it is unsymmetrical in shape, much more sharply defined on the side facing the carina than on the side facing the axis. The volutions embrace up to this ridge more or less precisely, so that it is inconspicuous in the spire; an ensuing volution is more apt to project a trifle beyond it than to fail in reaching it. Both conditions are sometimes found in the same specimen.

The surface is practically without sculpture and marked by growth lines alone but these though fine are very distinct. They are, however, slightly less distinct on the slit band than anywhere else. Except for the slitband they show a certain periodicity, for at fairly regular intervals an incised line or stria is somewhat stronger than the rest. They are slightly arched (convex side toward the aperture) and rather strongly oblique fom the suture backward; in the slitband itself, with a sharp change in direction, they form fine regular concave arcs; below the slitband they again abruptly change direction, becoming for a distance gently convex with a slant somewhat forward, though subsequently they straighten out and pass directly to the axis. It is impossible to give the locus at which this change in shape and direction takes place, for the change is at the same time gradual and slight, but in general terms the growth lines are curved and have an appreciable forward obliquity as far as the carina, and are straight and direct from the ridge below the carina to the axis.

The axis is solid; the peristome appears to be folded back upon itself in the axial region without creating an excavation or even an obscure false umbilicus. An inner lip seems to be developed, though commonly it is little in evidence. As a rule the inner lip merely dims or obscures the growth lines within the aperture; on an occasional specimen it makes a more substantial coating. The slit was probably very short. None of my specimens is complete at the aperture, but several appear to be but slightly broken, and even on these the slit is missing; the slit-band can be traced to the broken edge of the peristome.

The shell consists of two distinct layers, a fact which is very conspicuous in many of the specimens from the Franklin Mountains. In these specimens the outer layer has a polished look and a brownish color which, upon closer examination, is found to be a mottling of light brown and black. The growth lines also, though fine, are very clear. Where this outer layer is removed as it is entirely on some specimens and over parts of others, the inner and thicker layer is seen to be lusterless and almost black; it fails to retain or retains but faintly the lines of growth so that on specimens of this sort and on many specimens from other areas, it would be difficult to recognize the slitband as such and consequently the relation of these shells as belonging to the Pleurotomariidae. The type specimens together with other specimens that I have seen from Taos and also the specimens from Colorado are black and show the growth lines less clearly than those from the Franklin Mountains. I have not been able to satisfy myself whether they have lost the superficial layer or are merely not quite so well preserved. The latter explanation seems the more probable one.

Horizon and locality.—Magdalena limestone: Taos, New Mexico (station 6687); McCoy, Colorado (station 8606); 8 miles southwest of Vinton, Texas (station 7067) and other localities in the foothills west of the Franklin Mountains.

II. SOME HIGH-SPIRED PLEUROTOMARIAS FROM LA LUZ CANYON, NEW MEXICO

Rocks that have been classed as Magdalena limestone in various parts of New Mexico contain unlike faunas and may not have been deposited contemporaneously. In the first instance we have the typical Magdalena in the district of that name; in passing up the Rio Grande valley faunas of a different facies are found at Santa Fe and still more different ones at Taos; to the southeast rocks called Magdalena occur in the Sacramento Mountains and others still farther south in the Franklin and Hueco Mountains of Texas. Some of the faunal differences encountered in these different areas will probably prove to be provincial and due to selective environment, but I believe that age differences are also indicated.

In the Sacramento Mountains in La Luz canyon there is a considerable thickness of limestone and shale which seems loosely to have been classed as Magdalena but which contains a fauna different from the typical Magdalena and which is, if I am not mistaken, younger. The fauna in question is dominated by the gastropoda and appears to be related to some of the Cisco faunas of central Texas. It is remarkable for the number and variety of high-spired pleurotomarias such as were formerly classed in the genus *Murchisonia.* These shells came within the purview of collateral studies undertaken in connection with the new genus *Taosia.* I do not recall ever having seen these elongated pleurotomarias in such abundance and was interested, in view of the general similarity of their appearance, to find that they belong to three distinct genera, *Goniasma*, *Phymatopleura* and *Taosia*. The facts seem of sufficient general interest to be made a matter of record.

Before leaving this subject I may mention that the shale near Tularosa which furnished the cephalopods described by Boese[3] and later by Miller[4] belong to this same series of rocks. Both writers believe, and in my opinion quite rightly, that the cephalopods indicate a Pennsylvanian age. Boese, for some reason, thought that the beds at Tularosa represented the Abo sandstone and on that ground challenged the Permian age of the Abo. The Permian age of the Abo was never too secure and the formation may prove to be Pennsylvanian, but not on the evidence advanced by Boese. So far as I am aware, the typical fauna of the Abo (at the entrance to Abo Canyon) does not contain a single species in common with the fauna of the shale at Tularosa and especially contains none of the cephalopods on which the Pennsylvanian age of the Abo was predicated; and it seems strange to set up a claim that the Abo was Pennsylvanian instead of Permian on the evidence of fossils that did not come from any recognized outcrop of the Abo but were found in rocks at a remote locality and associated with a fauna quite different from the Abo fauna. It is probable that Boese did not know about the difference of faunal association in one sense, but he must have known that none of the species which led him to think that the Abo was Pennsylvanian in age had been identified in an Abo fauna.

Taosia percostata n. sp. Figs. 12–14

Shell of moderate size, very long and tapering, composed of a large number of angulated volutions. Spire much constricted at the suture to which the surfaces of the volutions converge from the angulation. Specimens are not rare, although owing doubtless to their slender shape, all of those examined are fragmentary. The largest seen does not have a diameter at the aperture as great as 10 millimeters. The length, the number of volutions, and other characters which are to be ascertained only from complete specimens, cannot be given.

In the final volution the angulation is situated at about the mid-height and it is reinforced, as of course it is in all the other volutions, by a carina which may be stout and rounded or more slender and angular. The surface between the suture and the carina is slightly concave with a steep descent from above. The surface below the carina is rounded and it has a fairly strong inward slope to its union with the solid columella. In the spire the carina is situated well below the middle of the exposed portion of the volutions, the long slope above having a steep descent and the short slope below passing more strongly inward. The almost flat upper surface of the volution is divided by two revolving lirae into 3 zones which are of about equal size

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[3] BOESE, EMIL. Am. Jour. Sci. (4) **49**: 51–60. 1920.
[4] MILLER, A. K. Jour. Pal. **6**: 59–93. 1932.

though the median one is apt to be somewhat the widest and the one below the suture somewhat the narrowest. The upper of the two lirae may be poorly developed or possibly even undeveloped, especially on some of the earlier volutions. The lower one, on the contrary, is regularly present. The lower surface of the last volution is rather coarsely and strongly striated, being marked by 5 or 6 stout revolving costae, separated by deep and somewhat wider grooves or striae. The volutions embrace to the second spiral costa below the carina, the top of which can be distinguished in many specimens as a slight projection above the suture. Transversely the surface is marked by fine growth lines which tend to form slender fascicles, although these are inconspicuous except on the lower surface where they may be sufficiently strong to produce nodes in places on the revolving costae.

The slitband is, with little doubt, the lowest of the 3 zones on the upper surface, that which is just above the carina. The growth lines descending from the suture have a backward slant and also a backward curve as they near the spiral lira that forms the upper boundary of this zone. Similarly on the lower surface of the last volution the growth lines are gently convex toward the aperture, and have a rather strong backward obliquity to, and apparently onto, the carina. The growth lines, which everywhere else are rather distinct, become fainter near the boundaries of this zone which itself rarely shows any markings at all. The inference is fairly strong from the deflection of the growth lines above and below it, that this zone is, in fact, the slitband, and the inference is strengthened by very rare occurrences there of growth lines that are distinguishable and that make characteristic concave arcs. The upper boundary of the slitband, then, is formed by the first revolving lira above the carina. The slitband does not, on the other side, extend to the edge of the carina but it is there as if abruptly depressed below a narrow elevated rim.

The upper surface of the volutions in this species shows a most deceptive resemblance to that of *Taosia copei*, but in *T. copei* the slitband occupies the median of the 3 zones into which the upper surface is divided, whereas in *T. percostata* it occupies the lowest zone. I am not sure that this should not constitute a subgeneric difference. In other respects, too, the species show marked differences. *T. percostata* has 5 or more spiral costae on the surface below the carina, whereas *T. copei* has but one. It also exposes a broader surface below the carina in the volutions of the spire, and that surface is divided by a stout revolving costa, whereas the corresponding part of *T. copei* is not only narrow but smooth. These differences contribute to make the shape of the shell as a whole markedly different in the two species, the present one being conspicuous for the depth of the spiral constriction at the bottom of which lies the suture. In shape *T. percostata* much more closely resembles the associated species *T. crenulata* and *Goniasma lasallensis*, but all three have such marked peculiarities in one or more details that with identifiable specimens there is no danger of confusion.

Horizon and locality.—Magdalena limestone (?); La Luz canyon, east of La Luz, N. M. (station 6686).

Taosia crenulata n. sp. Figs. 8–11

Shell rather large, very elongate, strongly turreted. Volutions probably 10 or more, though complete specimens are unknown. Spire perhaps twice as high as the final volution. Spiral angle variable, some specimens being very long and slender. Volutions strongly angulated, giving the shell a conspicuously helicoid shape. The angular periphery of the volutions forms a crenulated carina which may be very prominent and in the final volution is situated at about the mid-height but in the spire divides the visible part of the volutions very unequally—the lower part being much narrower than the upper.

The upper surface of the final volution is essentially planate and descends more or less steeply from the suture. It is traversed by two raised spiral lines defining the slitband. The three zones created in this way are of nearly the same width though the upper zone is apt to be a little wider than the slitband and the lower zone a little narrower. It is commonly somewhat concave spreading out to the carina.

The lower surface of the final volution is about equally divided between an upper part which is flat, depressed, and smooth and a lower part which is gently convex and coarsely costate, both parts descending with about the same inward obliquity until the lower one joins the solid columella. The costate part of the lower surface bears about five rather widely spaced revolving costae, of which the highest is especially large and strong and the lowest small and weak. The upper smooth part of the lower surface appears depressed because of its position between the prominent carina above and the first strong revolving costa below. The volutions overlap to the lower margin of the flat depressed zone, and the prominent costa below it is rarely distinguishable in the spire.

The surface, aside from the two raised lines on the upper surface that contain the slitband and the costae on the lower part of the lower surface (not visible on the spire), is practically devoid of spiral markings. Some specimens, however, develop an inconspicuous spiral line or faint angulation between the slitband and the suture. This feature may make its appearance on the later whorls without being distinguishable on the earlier ones of the same specimen. Sporadically, also, for it has been observed on only one specimen, a few fine irregular spiral lirae may be developed on the upper or sunken part of the lower surface and visible thus on the spire.

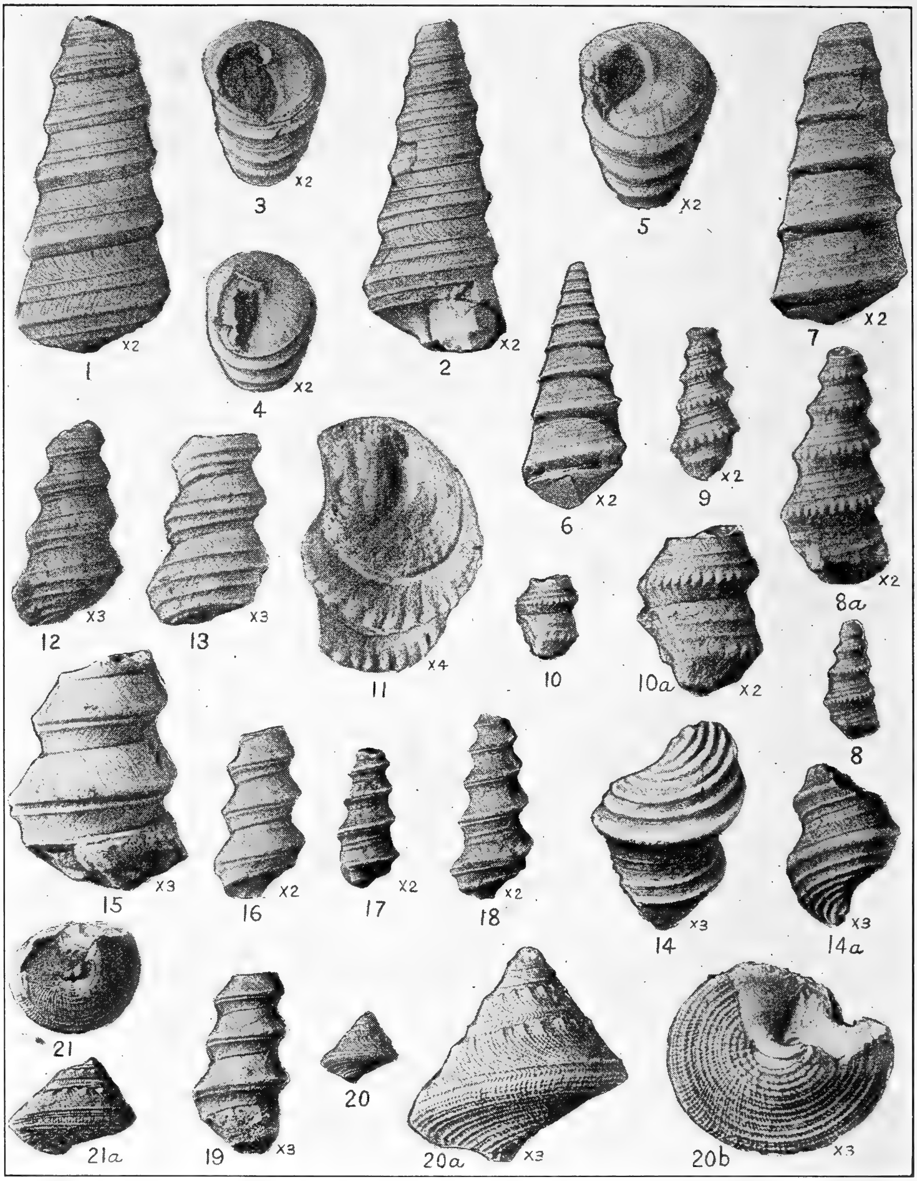
Transversely the surface markings consist of incremental lines which have at first a gentle convexity and a strong backward slant. They are rarely distinguishable in the slitband but where they can be made out they have the usual shape of short concave arcs. From the slitband to the carina they are again slightly convex and have a forward direction from above. On this zone the growth lines are more or less strongly and regularly fasciculate. The fasciculation is but slight at the slitband but near the carina it rapidly becomes very strong, producing the nodes or coarse strong crenulations above described. Below the carina the fasciculation is again greatly reduced, the fascicles being regular but weak.

It hardly seems necessary to specify the distinctive characters of *T. crenulata.* The nodose character of the carina distinguishes it at once from *T. copei* and from *T. percostata;* in addition, the costate lower surface of the volutions distinguishes it from *T. copei* and the position of the slitband from *T. percostata. T. crenulata* like *T. percostata* developed costae on the lower surface of the volutions but apparently the development differed materially in detail.

Horizon and locality.—Magdalena limestone (?); La Luz canyon, east of La Luz, New Mexico (station 6686).

Genus **Goniasma** Tomlin

When I propose the generic name *Goniospira* in 1915 the facilities for ascertaining names that were not available through preoccupation were not



Figs. 1–7.—*Taosia copei* White. Figs. 1–5. Five specimens from the Magdalena limestone (?) of the Franklin Mountains. These specimens show the growth lines very clearly. The photographs have been retouched but this character in figs. 1 and 2 has not been exaggerated. The original of fig. 2 has proportions similar to the larger of the two cotypes. Figs. 3, 4 and 5 show the basal surface of the final volution and the imperforate columella. Fig. 5 shows well the revolving lira on the lower surface of the final volution; it can also be seen in figs. 1 and 2. Fig. 2 appears to have a second lira, but the lower one is merely the broken edge of a volution that has been lost. The original of fig. 3 shows the inner lip more clearly than most specimens. It is thin but sufficient to conceal the growth lines along a very distinct line; the deposit is darker than the superficial layer and of the same tint as the inner layer of the shell. If the

what they are today. It seems that *Goniospira* had been used by Cossman in 1895 and by Donald in 1902 so that availing himself of this fact Tomlin[5] in 1929 proposed *Goniasma* as a substitute. The following species, *Murchisonia lasallensis* Worthen, which was made the genotype of *Goniospira* remains the genotype of *Goniasma.*

[5] TOMLIN, J. R. LEB. Malac. Soc. London, Proc. **19**: 22–24. 1929.

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basal part of the specimen is regarded as a circle, the inner lip occupies about one-sixth of the circumference from the line of matrix. This character is not brought out in the illustration. Figs. 6, 7. Unretouched photographs of the two cotypes from Taos, N. M., made by J. Brookes Knight, who sent me the prints here published. The cotypes have apparently lost the epidermal layer or at all events do not show the lines of growth at all clearly.

Figs. 8–11.—*Taosia crenulata,* n. sp. Four specimens from La Luz Canyon, N. M. The slitband is situated between the two spiral ridges on the upper surface of the whorls of the spire, the surface lying between the suture above and the nodose carina below. The growth lines slope backward to this zone from above and from below but the concave lines on the slitband are obscure or not visible at all. These features are shown by the originals of figs. 8 and 10. The original of fig. 8 has a faint auxiliary lira a short distance below the slitband and at least 2 fine and faint lirae on the surface between the carina and the suture below. Fig. 11 shows the lower surface of the final volution with its solid columella and spiral lirae. The large spiral lira may be compared to the one similarly placed on *Taosia copei.*

Figs. 12–14.—*Taosia percostata,* n. sp. Three specimens from La Luz Canyon, N. M. These specimens have only one regular revolving lira on the whorls of the spire between the suture above and the carina below and on the original of fig. 13 the carina is not much the larger of the two. This specimen has a faint auxiliary lira which is not well shown by the figure a short distance below the suture. In fig. 14 a corresponding lira is shown, but the regular lira forming the upper boundary of the slitband is hardly visible due to the prominence of the carina and the foreshortening of the surface immediately above it. The growth lines slope backward to the regular revolving lira which marks the upper limit of the slitband; the lower limit is indistinct but is on or just above the top of the carina. The slitband here is above the carina as it is in *Taosia copei* but instead of being situated about midway in the upper surface it occupies the lower third. Fig. 14 shows the strong spiral costae on the basal part of the final volution.

Figs. 15–19.—*Goniasma lasallensis* Worthen. Five specimens from La Luz Canyon, N. M. In this species and genus the slitband has a position corresponding to that of *Taosia percostata,* except that it is just below instead of just above the carina. The growth lines slope backward from below (well shown by the originals of figs. 15 and 16) and apparently come to an end at the spiral costa below the carina which forms the lower limit of the slitband. Its upper limit is indistinct but is situated upon the crest or just below the crest of the carina. The growth lines on the upper surface of the volution bend backward near the carina and can be traced to its crest. The lower surface of the final volution has a prominent angulation or lira somewhat as in *Taosia copei.* Fig. 17 should be more strongly angulated.

Figs. 20–21a.—*Phymatopleura brazoensis* Shumard. Figs. 20–20b. Three figures of a specimen from the Wayland shale, near Graham, Texas (station 7442). This specimen has about 13 spiral lirae on the lateral surface with about 3 additional ones on the nodose ridge below the suture. This is only one of numerous varieties that can be found in a large collection. Fig. 20b shows how the "inner lip" is really a resorbed area. The sculpture at the left comes to an end abruptly along a well defined line at or near the aperture while the smooth area to the right stands at a lower level. Figs. 21–21a. Two views of a specimen from the upper part of the Graham shale at Graham, Texas. In this specimen the nodes are farther apart and the slitband has an auxiliary lira below the median one so that the lower half of the slitband, in that degree, appears to be a part of the under surface.

Goniasma lasallensis Worthen

Murchisonia lasallensis. Worthen, Illinois Geol. Survey, Rept. **8:** 141, pl. 25, figs. 7, 72. 1890. Upper Coal Measures: LaSalle, Ill.

Worthenia? lasallensis? Girty, U. S. Geol. Survey, Prof. Paper **16:** 457. 1903. Hermosa formation: San Juan region, Colo.

Goniospira lasallensis. Girty, Missouri Bureau Geol. & Mines (2) **13:** 356, pl. 30, figs. 7–8a. 1915. Lansing formation: Kenmoor, St. Joseph, Weston, Leavenworth, Lansing, Iatan and Smithville, Mo.

It was perhaps somewhat rash to correct Worthen's description on the strength of my specimens without having seen his, but his description is evidently deficient in details that are apparently shown by his figures as well as being self-contradictory. The corrections which I ventured to make concern the features described in these terms. "On the last volution there is a flattened band below the carina which is bounded below by a slight elevation." The form from Missouri that I referred to *G. lasallensis* and consequently the one on which the genus *Goniospira* was in the final analysis based answers to this description except that in my form both the carina and the elevation below it are double. That is, the carina has a revolving lira a short distance below it and the "slight elevation" is formed by two revolving lirae separated by a narrow groove. In Worthen's schematic figure each of these features is represented by a double line. This suggests that each line represents the top of a ridge and as such an interpretation agrees with the character of my form, it seems to be the correct one. Each pair of lines, however, may be intended to outline a single ridge. One important omission in Worthen's description is his failure to specify the location of the slitband. As the slitband so commonly occupies the carina in the Pleurotomariids, perhaps such a position is implied. The slitband in my form does indeed occur there but it is not situated on the carina which is angular but just below it, its lower boundary being formed by the revolving lira that accompanies it. Worthen's reference to a "flattened band" in the passage quoted above and his failure to mention the slitband in any other way led me to believe that that expression was intended to designate the slitband. This probably was a misconception. Worthen also says, "Neither the flattened band nor the elevation below it extend to the other volutions." This is certainly not true of my specimens and it obviously is not true of Worthen's for it is contradicted by his figures and by another part of his description in which he says that the volutions "are separated by a profound suture." The expression just quoted agrees with his figures which represent the shell as being screw-like in shape, the lower side of each angulated whorl of the spire being nothing else than the aforesaid "flattened band." If the flattened band did not show in the volutions of the spire the volutions would embrace to the carina, and the spire would have smooth sides instead of being made sinuous by a deep constriction. In the form on which the genus Goniospira was based the volutions embrace to the paired lirae on the lower surface.

A species which can be identified with *Goniasma lasallensis* is very abundant at one locality in La Luz Canyon but as the specimens are considerably broken up their abundance is somewhat exaggerated. I have been unable to find any constant difference between the specimens from New Mexico and those from Missouri which I described in 1915. As compared with Worthen's figures of the type, some of them appear to be more slender and many appear to have the constriction in which the suture is situated considerably deeper so that the sides of the spire are correspondingly more uneven. A few of these specimens developed a spiral thread on the lower surface of the volutions, midway between the slitband and the paired lirae below, on Worthen's "flattened band," that is.

In examining these specimens from New Mexico especial attention was directed to the slitband which is somewhat peculiar in not being as sharply defined as the slitband of most pleurotomarias and in lacking these lunettes or regularly spaced, concavely arched transverse lamellose lines by which the slitband is so commonly distinguished. The slitband is of course distinctly defined on its lower side but not on its upper, except by the angular or, in many specimens, rounded edge of the carina. Its identity, however, is shown by the deflection of the growth lines. As they descend from the suture, the growth lines are essentially straight and have a slight backward slant which, however, increases near the carina, giving them a curved appearance. They are apt to be faintly fasciculate in the upper part and to become somewhat less distinct below though on many specimens they can be seen running out onto the upper surface of the carina. Coming up from the suture below, the growth lines are also distinct to the revolving lira below the carina, but not beyond. They are nearly straight and commonly have a very pronounced backward slope toward the carina. Thus, it will be seen that the slitband as represented by the narrow channel between the carina and the lira below it, often fails to show even growth lines, though where they can be distinguished they have the characteristic shape of concave arcs. As stated above, while the slitband is not bounded on its upper side in the same way as on its lower, and to some extent does not appear to have a sharp boundary at all, many specimens show an incised line on the carina either following the crest of the carina or more commonly following a line just above the crest. Where most distinct this incised line on the carina is similar in appearance to the suture at the bottom of the constriction above, but on a smaller scale. The backwardly-curved ends of the growth-lines can sometimes be traced to this boundary at which they appear to terminate. This feature has been observed on so many specimens that I am inclined to believe it to be a constant one, with this qualification; it is most commonly observed where the carina is thick and rounded as the carina is apt to be on the larger whorls, and it is doubtfully to be observed where the carina is thin and sharp as the carina commonly is in the smaller ones. Accordingly, it would be a character that developed toward maturity. I am also inclined to believe that this incised line marks the real boundary of the slitband. The inference may possibly be drawn that as the shell increased in age the deposits at the slit, which create the slitband, became thickened, but thickened unequally, with the greatest accumulation in the upper part and that the size of the carina was increased by this accumulation.

Locality and horizon.—Magdalena limestone (?); La Luz canyon, east of La Luz, New Mexico (station 6686).

III. PHYMATOPLEURA, NEW GENERIC NAME, WITH COMMENTS ON P. BRAZOENSIS (SHUMARD)

When I proposed the generic term *Orestes* in 1911[6] for certain Pleurotomarioid shells, my investigations into nomenclature, which

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[6] GIRTY, G. H. New York Acad. Sci., Annals **21**: 136. 1911; also U. S. Geol. Survey, Bull. **544**: 155. 1915.

were sincere but not comprehensive, indicated that the name was not preoccupied and the unusual character of the name itself, which was meant to commemorate the work of Orestes St. John, seemed a certain guarantee that it was not. My good friend J. Brookes Knight warned me some time ago that *Orestes* was preoccupied as a generic name and in fact I find that it had been used by Blackiston and Pryer, as long ago as 1880 and again by Redtenbacher in 1906. I take this opportunity, therefore, to propose *Phymatopleura* as a substitute with of course the same species, *Orestes nodosus* as the genotype.

I did not at the time know of, nor have since then come upon, any other species that could certainly[7] be grouped with *Orestes nodosus* except a little known species from Texas described by Shumard as *Pleurotomaria brazoensis.* It seems appropriate in this place to give a supplementary account of *Phymatopleura brazoensis* which was poorly described without illustrations.

In establishing *Orestes nodosus* as a new species, I compared it with *Pleurotomaria brazoensis,* using not only Shumard's description of that species but specimens from the Cisco formation that seemed to belong to it. The species from the Cisco that was employed in those comparisons is clearly the one that Plummer and Moore later figured as *Orestes brazoensis;* and not only is it certain that we are dealing with the same species, but it is almost equally certain that we are dealing with the species which Shumard described and which has lain for so long unrecognized.

With specimens from the original locality and horizon the species can be identified with reasonable certainty but not otherwise. Consequently we find Meek in 1866 and Keyes in 1888 referring to *P. brazoensis* forms which were not only distinct from that species but distinct from each other. Meek's form is now known as *Pleurotomaria intertexta;* that of Keyes, so far as I am aware, is without a name. The figures given by Plummer and Moore show the general character of *P. brazoensis* but they are too small to show the sculpture in detail. Their figures were unaccompanied by a description just as Shumard's description was unaccompanied by figures and as Shumard's description is hard to come by (the work in which it was published being now rare) and as Plummer and Moore's figures are somewhat inadequate, it will be helpful to supply what seems to be lacking in each. Shu-

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[7] It is not improbable that the *Pleurotomaria brazoensis* of Meek now known as *Pleurotomaria intertexta,* less probably the *Pleurotomaria brazoensis* of Keyes also belong under *Phymatopleura.* I have not, however, examined specimens of either species. Even if congeneric, however, both of them seem to be distinct from either *P. nodosa* or authentic *P. brazoensis.*

mard's description will be found below and the synonymy which precedes it comprises all the legitimate citations of the species.

Phymatopleura brazoensis (Shumard)

Pleurotomaria brazoensis. Shumard, St. Louis Acad. Sci. **1**: 624. 1860. Coal Measures: Young Co., Texas, near Indian Reserve.

Orestes brazoensis. Girty, U. S. Geol. Survey, Bull. **544**: 158. 1915.

Orestes brazoensis. University of Texas, Bull. **2132**: 151, pl. 22, fig. 16, 16a. 1921. Graham formation (Wayland shale); South of Gunsight (loc. 80.2), Texas.

Shell small, conical, height a little greater than the width; spiral angle 67°; volutions about seven, flat or slightly concave, marked at base with two revolving carinae, between which occurs the band of the sinus; lower carina the larger and rounded; under surface of last volution somewhat tumid in the umbilical region, and flattened towards the periphery; suture depressed, linear; aperture subquadrate; columellar lip deflected above and partially closing in the umbilicus, which is very small; surface of volutions ornamented with from thirteen to fourteen rather strong, filiform striae, which are crossed by sharp transverse striae, giving to the surface a handsome, crenulated appearance; upper margin marked with a row of rather prominent lengthened tubercles; band of sinus moderately broad, excavated, having a single revolving line, and numerous arched transverse striae, corresponding in size to those above the band.

Length, 0.32; width, 0.29.

Formation and locality.—Young County, near the Indian Reserve. Found in bluish-gray marl, associated with *Myalina subquadrata*, *Chonetes mesoloba*, *Straparollus catilloides*, *Fusulina*, and other characteristic fossils of the Coal Measures. Texas State collection.

Shumard, I suspect, intended to write "cancellated" instead of "crenulated" in the above description (see also a comment by Meek) and he leaves the reader in doubt whether the "thirteen to fourteen" striae represents the total number on both the lateral and lower surfaces or the number on only one surface—if so, which? As he says that these striae are to be seen on the surface of the volutions (note the plural) and as only the lateral surface is to be seen on any volution but the last, it seems probable that he was ascribing 13 or 14 striae to that surface alone. This also agrees with his description of the surface as cancellated (if that was actually what he intended to say) for that term is very descriptive of the lateral surface but is much less applicable to the lower surface. Aside from this his description is quite accurate though, as it proved, hardly specific enough to prevent misinterpretation for neither Meek's form nor Keyes' closely resembles true *P. brazoensis*. The description is unsatisfactory chiefly in what is omitted in the way of detail and of the range of variation, for a good suite of specimens such as can be obtained with little difficulty (the species seems to be not uncommon in the general region and at the general horizon from which it was described) discloses that specimens which must be included in the species can differ rather widely. My own observations, which are summarized in the following paragraphs, are based upon about 100 specimens of all sorts.

In the final volution the slitband is broad, oblique, and situated on the periphery which is at about the mid-height. The surface above is oblique and more or less concave, spreading outward near the slitband and ending in a knife-edged ridge which forms the upper boundary of the slitband. The surface, coming up from below, rounds inward slightly to inclose the slitband on its lower side; the slitband thus does not appear to be bounded below by a sharp ridge or lamella as on the upper side. In such specimens the most prominent part of the volution occurs just below the slitband. Sometimes, however, the surface just below the slitband, instead of being sharply rounded and prominent, retreats almost immediately and then the slitband appears to be bounded by a knife-edged ridge below as well as above. The volutions embrace almost to the slitband so that the suture has above it a very narrow and slight prominence, the peripheral region of the preceding volution, and below it a wider and more prominent ridge formed by the upper part of the volution following.

The feature last mentioned varies almost from specimen to specimen. In its most intensified form it is a well marked, broad, rounded ridge with additional elevations at short and regular intervals. In its least development both ridge and nodes are almost, if not entirely, obsolete. This, however, seems to be a condition of old age and it has been observed only on the final volution of a few specimens whose earlier volutions are marked in the normal manner.

The swollen zone below the suture may be broad or narrow and high or so low as to be hardly signalized at all except by the nodes that rise from it. The nodes may be rounded and hemispherical but more commonly they are somewhat elongated and compressed so as to be subangular on top. At the opposite extreme they are very thin and high, as if formed by one of the transverse lirae which, at a definite point below the suture, abruptly becomes thick and prominent. The nodes vary not only in shape but in strength and in spacing. They may be close together or much farther apart, and very conspicuous or very subdued, though always a feature sufficiently pronounced to attract the eye.

The side of the volution between the nodiferous zone and the slitband is marked by fine, regular transverse and revolving lirae of nearly equal strength and spacing, which make a regular reticulate ornamentation. On some specimens the intersection of these cancellating lines is marked by fine raised points, like short spinules, and probably this is a regular feature, though one not commonly preserved.

Three or four of the spiral lirae occupy the swollen or nodose zone below the suture and these are commonly somewhat coarser than the rest; indeed, they may be much coarser. On the remainder of the lateral surface the number of spiral lirae may vary from about 10 to almost 20. Where the number is exceptionally large it may be attributed to the introduction of interstitial lirae, the character of which is occasionally suggested by their smaller size; this tends to create a sort of irregular alternation, though any pronounced alternation in size is exceptional. The difference in scale between the coarsely and finely striated shells is so marked that if extreme examples of each were found without intermediate forms and especially if found at different localities, they would undoubtedly be regarded as belonging to different species. The spiral lirae are commonly slender and rounded, but may be appreciably stouter with a corresponding difference in spacing in which, of course, number also plays a part. The transverse lirae are thinner than the spiral ones, much like low, vertical lamellae. They may be spaced at the same intervals but may be much more closely arranged. Normally, however, the spiral lirae are numerous and essentially uniform in size, the transverse lirae slightly thinner and spaced at the same intervals, and the result a very regular and very fine cancellation.

Typically the slitband contains a single revolving lira, which may be very slender or relatively stout. Not uncommonly a second smaller lira is developed above or below the median one (as in figure 21a) and in a few specimens an additional lira is developed on both sides of it. The three lirae may be equal in size but more commonly the median one is the largest. Transversely the slitband is crossed at regular intervals by short slender raised lines in concave arcs, which in crossing the spiral lira (or lirae) create very small nodes. The transverse lirae in the slitband are rather commonly spaced at appreciably wider intervals than those on the lateral surface. On some specimens they are irregular in size and spacing, as if by intercalation, and where this occurs they may be more closely arranged than the transverse lirae above.

The basal surface is marked in much the same way as the lateral surface, only more coarsely, especially as regards the spiral lirae. These are on the whole thicker than the revolving lirae of the upper surface and are subject to greater inequality in size. Some of the large ones may be very large and some of the small ones very small and sometimes a more or less regular as well as a strong alternation in size can be observed. In number the revolving lirae may reach 20 or more. Although the lower surface is somewhat broader than the lateral surface and although it may not have many more revolving lirae, it appears more coarsely as well as more irregularly lirate because the lirae are thicker, and, where especially thick, they are rather crowded. A few lirae (4 more or less) on the sharply curving surface below the slit band are generally subequal in size and not so large as the larger ones on the rest of the lower surface while a few near the false umbilicus may attain a relatively enormous size.

The transverse lirae are thin and lamellose like those of the lateral surface and on the same specimen they have about the same spacing on both. A comparison in this item is difficult, however, because the transverse lirae above the slitband have to contract much less in passing upward to the suture than those below the slitband do in passing inward to the axis. Just below the slitband they may be larger and more widely spaced than they are just above it (or on the other hand, essentially the same in both respects), but shortly are reduced to or remain at parity. In crossing the lower surface to the axis they not only become finer but draw together with a tendency to coalesce.

As they converge toward the axis they become more or less strongly fasciculate and give rise to correspondingly large strong nodes on the exceptionally large spiral lirae that occur there.

The characters not touched upon are chiefly generic. The axis seems to be imperforate, though the inner lip is thickened and reflexed to form a small false umbilicus. Instead of an inner lip the surface markings are resorbed so that the surface within the aperture is smooth and slightly depressed below the sculptured surface outside of it.

It was probably this species which I cited as *Pleurotomaria Brazoensis* in listing the collections made in Missouri by Hinds and Greene.[8] The specimens so identified are fairly numerous but most of them are so incrusted that their characters are imperfectly shown. These and other similar specimens from Oklahoma which I have seen at first appear to be distinct from *P. Brazoensis* by reason of their finer sculpture but they are also of a correspondingly smaller size. The general features appear to be about the same. Specimens from Texas vary so much in their sculpture that some do not differ materially from those from Missouri, and the specimens from Missouri differ from each other in this feature or in that. If the Missouri form is regarded as specifically distinct from the Texas forms there are differences in the content of each which are apparently equal in significance to the differences between them.

PALEOBOTANY.—*The fruit of* Trapa? microphylla *Lesquereux.*[1]

ROLAND W. BROWN and EDGAR HOULDSWORTH.

The complete four-parted rosettes of floating, compound leaves as well as the detached leaflets of plants purporting to be a species of water chestnut or caltrop called *Trapa? microphylla* Lesquereux, have long been known from Cretaceous and Eocene strata of the western interior of North America.[2] The surfaces of some slabs of rock, notably those from the Fort Union formation (Eocene) at Burns Ranch, 30 miles down the Yellowstone River from Glendive, Mont., are covered with them. Although much leaf material has been collected from this and numerous other localities in Wyoming, Montana, and Canada, none, until recently, was found with fruit attached. The specimens displaying fruit that are reported here were found in 1936 by Mr. Edgar Houldsworth of Regina, Saskatchewan, Canada, in the Ravenscrag formation (Eocene) cropping out in sec. 4, T. 2, R. 22 west of the 2nd meridian, in the Big Muddy Valley region of southern Saskatchewan.

The finding of these specimens with fruit attached establishes the affinity of numerous detached fruits that were found in previous collections but whose identity remained a mystery. Some of these have been figured and described as *Carpolithus, Viburnum, Nyssa,* etc. It is, however, not our purpose to give a synonymy of these species at this time.

The fruit of *Trapa? microphylla* averages 1 cm in length, is ovoid, the apex being slightly elongate and emarginate or cut at the end

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[8] Missouri Bureau of Geology and Mines (2) **13**: 305. 1915.

[1] Published by permission of the Director, Geological Survey, Department of the Interior. Received November 21, 1938.

[2] E. W. BERRY has recently summarized the history and knowledge of this species in Geol. Survey Canada Mem. **182**: 61–64, pl. 19, figs. 1–11. 1935.

as shown in the better preserved specimens, Figs. 4, 5, 8. The surface displays several prominent, longitudinal bulges and depressions which appear to have been folds that either were present in the living fruit or were initiated at the beginning of fossilization. These fruits were attached by short, stout peduncles to the stem beneath the rosette of floating leaves, somewhat in the same manner as the nuts of living species of water chestnut, *Trapa.* Fig. 1 shows one attached fruit partly overlain by another that is not fully uncovered but presumably belongs to the same plant. It seems probable therefore that *T.? microphylla* produced more than one fruit on a single plant. Nothing is known about the seed or seeds borne in these fruits.

Inasmuch as the fruit here shown to be part of the species *Trapa? microphylla* is without the horns so characteristic of the living species of *Trapa,* and because the leaves of this species are compound, not simple as in living species of *Trapa,* the propriety of the question mark used by Lesquereux becomes doubly apparent. However, these divergences do not necessarily preclude a possible relationship, not too distant, with living *Trapa,* for diversities of foliage and fruit just as great can be matched in many other families of flowering plants. It may be noted that Dawson[3] reports horned nuts called *Trapa borealis* Heer from the same strata on the Red Deer River and Rosebud Creek in Alberta, Canada, that also yield "leaves not distinguishable from those [*T.? microphylla*] described and figured by Lesquereux." Despite this association it is clear now that the horned nuts must have been produced on a different plant, the foliage of which has not yet been found or has not been recognized as that of *Trapa.* Thus far, although several fossil species of *Trapa* fruit have been reported from strata in North America,[4] no foliage positively assignable to *Trapa* has yet been identified.

Some of the Houldsworth specimens, not figured here, yield additional information, not hitherto reported in regard to *Trapa? microphylla.* The quartered rosette of compound leaves that is most commonly the portion found, has for some time been suspected of being the floating part of the plant that appeared on the surface of the water. One of the Houldsworth specimens, and more clearly, a specimen (Fig. 3) from Wyoming shows fimbriated and filiform submerged leaves beneath the rosette of floating leaves. Other specimens indicate

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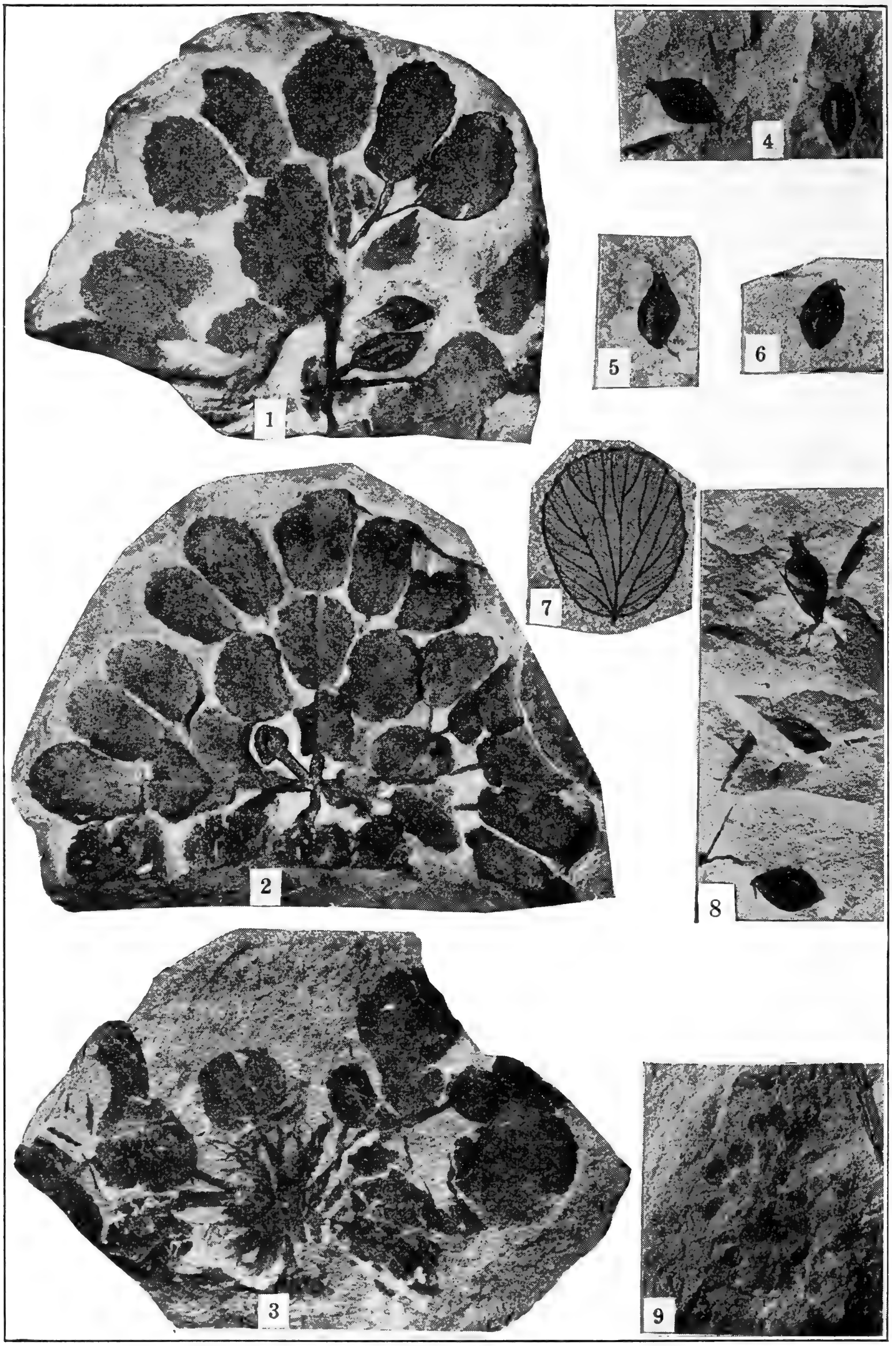
[3] DAWSON, J. W. *On fossil plants from the Laramie formation of Canada.* Roy. Soc. Canada, Trans. **4** (sec. 4): 31, pl. 2, fig. 19. 1886.

[4] BROWN, ROLAND W. *Miocene leaves, fruits, and seeds from Idaho, Oregon, and Washington.* Jour. Paleont. **9**: 581, pl. 67, fig. 17. 1935.—*Additions to some fossil floras of the western United States.* U. S. Geol. Survey Prof. Paper **186**: 183, pl. 55, figs. 5, 6. 1937.



Figs. 1–9.—For explanation see opposite page.

indefinite lengths of slender, tubular, perhaps noded, stem to which the rosette and fruits were attached. If the broken enlargement at the end of one of these stems was a root or holdfast, the stem could not have been more than 8 cm long, but complete specimens must be had to confirm this point. At any rate these additional facts affirm the inference that *T.? microphylla* was a hydrophyte with morphology and habits comparable to those of *Trapa natans* today.

ORNITHOLOGY.—*A genus and three new forms of birds from Borneo.*[1] J. H. RILEY, U. S. National Museum. (Communicated by H. Friedmann.)

In identifying material collected by Doctor W. L. Abbott and H. C. Raven in Borneo, the following genus and three forms of birds are believed to be unnamed. They may be known from the following descriptions:

Elocincla aenigma gen. et sp. nov.

Type.—Adult male, U. S. National Museum, No. 181562, Klumpang Bay, Southeast Borneo, March 5, 1908. Collected by Dr. W. L. Abbott.

Similar to *Malacocincla* Blyth, but tail shorter than the tarsus, instead of much longer.

The type and only species may be described as follows:

Similar to *Malacocincla rufiventris* Salvadori, but bill and tail shorter.

Description.—Pileum deep neutral gray washed with olive brown; back and outward surface of the wings cinnamon brown, becoming slightly more reddish on the upper tail-coverts; tail mars brown; lores and cheeks deep mouse gray, the auriculars washed lightly with olive brown; throat and jugulum white, the latter with obsolete dusky streaks; chest, sides, belly, and crissum cinnamon; middle of the breast buffy white. Wing, 71; tail, 25.5; culmen, 16; tarsus, 27; middle toe and claw, 22.

Remarks.—The present species is founded upon four specimens, as follows: the type; one male and one female, Kapuas River, West Borneo; and one female, Ritan River, East Borneo. There is some little variation in the four

[1] Published by permission of the Secretary of the Smithsonian Institution. Received November 15, 1938.

Fig. 1.—*Trapa? microphylla* Lesquereux with two fruits, one of which is attached beneath the center of the rosette of floating surface leaves. Ravenscrag formation (Eocene), sec. 4, T. 2, R. 22 west of the 2nd meridian, Saskatchewan, Canada. Collected by Edgar Houldsworth. Fig. 2.—Specimen showing one misshapen attached fruit. Ravenscrag formation. Fig. 3.—Specimen showing fimbriated submerged leaves beneath the rosette of surface leaves. Meeteetse formation (Cretaceous), SE $\frac{1}{4}$ sec. 10, T. 46 N., R. 98 W., Wyo. Collected by D. F. Hewett. Figs. 4–6, 8.—Detached fruits. Fort Union formation (Eocene), left bank of the Yellowstone River at Burns Ranch, 30 miles northeast of Glendive, Mont. Collected by Lester F. Ward. Fig. 7.—Sketch of leaflet showing venation. After Lesquereux, *The Tertiary flora*, U. S. Geol. Survey of Terr., vol. 7, pl. 61, fig. 16, 1887. Fig. 9.—Small rosette. Meeteetse formation, NE $\frac{1}{4}$ sec. 2, T. 45 N., R. 98 W., Wyo. Collected by D. F. Hewett. All figured specimens are in the U. S. National Museum.

specimens. In one female there is little white on the breast and the dusky streaks extend forward onto the throat. In two of the specimens the pileum is deep neutral gray without any olive brown wash. The four birds have been compared with five skins of *Malacocincla rufiventris* from Dutch East Borneo and they are remarkably alike in plumage. The latter on the average is a more reddish brown above and the pileum is more heavily washed with brown, sometimes entirely brown. It is remarkable how close the two species resemble each other in plumage and for this reason *Elocincla aenigma* has been overlooked, but the latter can always be distinguished by its shorter tail and bill; it is also somewhat smaller.

The four specimens of *Elocincla aenigma* measure: wing, 66.5–75 (70); tail, 23–25.5 (24.7); culmen, 15–16 (15.5).

The five specimens of *Malacocincla rufiventris* measure: wing, 71.5–75 (73.9); tail, 40–46.5 (43.3); culmen, 17–18 (17.2).

In my opinion *Malacocincla sepiaria* and *Malacocincla rufiventris* belong to two distinct form groups.

Ptilopyga Sharpe[2] (type *Malacocincla rufiventris* Salvadori) is a synonym of *Malacocincla* Blyth.

Iole olivacea perplexa subsp. nov.

Type.—Female, U. S. National Museum, No. 182491, Labuan Klambu, East Borneo, June 28, 1913, collected by H. C. Raven (original No. 909).

Similar to *Iole olivacea charlottae* Finsch, but smaller, the tail a more reddish brown above, the greater wing-coverts and inner remiges edged outwardly with hazel instead of light brownish olive; under tail-coverts ochraceous-tawny rather than ochraceous-buff or colonial-buff. Wing, 78; tail, 72; culmen, 16.

Remarks.—Raven took two females at the type locality on the same day. It may be the hazel edging to the wing-coverts and inner remiges denotes that the specimens are not fully adult, but they are about full grown and it seems hardly likely that there would be any great increment in size. The other female measures: wing, 78; tail, 73; culmen, 16.

Two males of *Iole olivacea charlottae* measure: wing, 88–91; tail, 72–73; culmen, 18–20.5; two females: wing, 82.5–90; tail, 72.5–74; culmen, 18.5–19.

Arachnothera affinis pars subsp. nov.

Type.—Adult male, U. S. National Museum, No. 182150, Birang River, Dutch East Borneo, October 9, 1912. Collected by H. C. Raven (original No. 276).

Similar to *Arachnothera affinis modesta* of the Malay Peninsula, but the lower parts lighter and less greenish yellow; the throat and breast more heavily streaked with dusky; above there is not much difference between the two forms; the Bornean race is on the average more greenish, less yellowish on the upper parts; wing, 89; tail, 55; culmen, 40.

Remarks.—The above race is founded upon three males and two females from Dutch East Borneo. These have been compared with a large series from the Malay Peninsula and Sumatra and they stand right out as described above. A single male of *Arachnothera affinis everetti* from Mount Kina Balu has been examined and *A. affinis pars* resembles it in color but is not so dark below or so greenish above; in size the Kina Balu specimen is somewhat larger; it measures: wing, 95; tail, 61; culmen, 42.5. Seven males

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[2] Cat. Birds Brit. Mus. 7: 507. 585. 1883.

and seven females from the Malay Peninsula (the type locality of *modesta* is Malacca) measure: wing, 70–86 (78.2); tail, 39.5–52 (45.5); culmen, 33–40 (35.7). Three males and two females from East Borneo measure: wing, 76–89.5 (82.4); tail, 44.5–57 (49.6); culmen, 35–40 (37.3). Sumatran specimens are slightly more yellowish green above than Malay Peninsula birds and appear to be a little smaller. Three males and three females from Sumatra measure: wing, 72–83 (77.7); tail, 39–50 (44); culmen, 31–35 (32.8).

Arachnothera affinis affinis of Java is much more yellowish above than the Bornean series and below is darker, more grayish; it is rather heavily streaked below like the Bornean form, however. Two males and one female from Java measure: wing, 78–91 (84); tail, 47–59 (52.2); culmen, 33.5–36 (34.5).

Whether *Arachnothera affinis pars* is confined to Dutch East Borneo or not is not known at present, but it seems incredible that such a well-marked form should have escaped naming so long, if it was more generally distributed upon the island.

ZOOLOGY.—*Crabs as food in India.*[1] A. RAMAKRISHNA REDDY, Annamalai University, S. India. (Communicated by WALDO L. SCHMITT.)

Crabs are used extensively for food in India, particularly in all provinces that border on the sea. In Bengal the crabs fished are *Scylla serrata* (Forskål), *Neptunus pelagicus* (Linn.), and *Charybdis crucifera* (Fabr.). *Scylla* is the most important and is very much relished by the Bengalese. The other two only occasionally are brought to market. In Bengal the freshwater *Parathelphusa spinigera* (Wood-Mason) and the esturine *Varuna litterata* (Fabr.) are taken for domestic use by the poorer classes.

Along the coast of Bombay and Sind, *S. serrata*, *Neptunus sanguinolentus* (Herbst), and *C. crucifera* are most frequently caught. The *Parathelphusa* fished in this region is *P. jacquimontii* (Rathbun).

In Madras, *N. pelagicus*, *N. sanguinolentus*, *S. serrata*, *Matuta victor* (Fabr.), and *C. crucifera*, listed in the order of their importance, form a large scale fishery. Here the freshwater species consumed locally are *Parathelphusa hydrodromus* (Herbst) and *P. bouvieri* (Rathbun).

Scylla reaches a large size, 8 to 12 inches in width. In Chilka Lake it may attain a width of a foot and a half! *Charybdis* also grows to a large size, but *Neptunus* not over 8 inches in width. *Parathelphusa* ranges from 2 to 5 inches, while *Varuna* never exceeds 2. *Matuta* grows slightly larger than *Varuna*.

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[1] Prepared in response to an inquiry from Dr. Waldo L. Schmitt, of the United States National Museum. I am indebted to Dr. B. N. Chopra, of the Indian Zoological Survey, Calcutta, for assistance in the preparation of this article and also to the Director of Fisheries, Government of Madras, the Director of Industries, Government of Bombay, and the Fisheries Expert with the Government of Bengal. Received December 22, 1938.

In taking *Scylla* commercially[2] a stout bamboo pole is firmly planted on one bank of a creek where the crabs are found. One end of a strong line is attached to this pole. The other is rowed to the opposite bank. From it are suspended a number of smaller lines bearing baits secured to slip nooses. In their efforts to carry off the bait, the crabs are caught in the nooses. Then the line is slowly pulled in and the crabs removed to the hold of the boat, where they may be kept alive for many days. *Scylla* is captured on a small scale by means of an iron hook affixed to a bamboo pole which is used to pull the crab out of its burrow. For the more active swimming crabs, *Charybdis* and *Neptunus*, sieve-nets are used.

In Bengal, large numbers of *Varuna* are obtained for domestic use with circular dipnets like those used for the capture of the soft-shelled blue crab, *Callinectes sapidus*, in America. The *Parathelphusa* fishery of Madras also employs dipnets. In and around Bombay this crab is caught in large numbers in light traps similar to those used in America for hard-shelled *Callinectes sapidus*.[3] *Parathelphusa* is also secured by means of a long stick ending in a swollen knob and provided with a bamboo sleeve which may be slipped down against the knob. This implement is inserted into the crab's burrow. When the crab takes hold of the knob, the bamboo sleeve slips down over its claw, clamping it so tightly that the crab may be successfully pulled out.

In Madras crabbing is an important occupation. A "hook and line" like that employed for catching fish is used. *Hippa* is the common bait. In back waters, floating crab traps are used. Crabs on the west coast are caught in small quantities mainly in cast nets, but also in seines and trawl nets along with fish. In the Gulf of Manaar and Palk Bay wicker traps are common.

Crabs are usually fried or served as soup. From *Scylla* and *Neptunus* only fried dishes are prepared, as follows:

> Break the shells of 10 of these crabs so that the animals may be immersed in water, discarding the carapace, gills, and legs. Boil for 15 minutes, after which add 2 tablespoons of chili powder, $\frac{1}{4}$ teaspoon of cinnamon bark, 2 tablespoons of coriander powder, and $\frac{1}{2}$ teaspoon of salt. Boil for about 5 minutes more. Meanwhile, fry 4 teaspoons of onion chips and one teaspoon of peeled garlic in ghee, gingilee oil, or cocoanut oil until the ingredients turn yellow; also fry separately 6 cloves and 4 pods of cardamon. Add all the fried ingredients to the boiling crabs and continue boiling for 2 or 3 minutes more.

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[2] Hora, S. L. *Crab fishing at Uttarbhag, Lower Bengal.* Current Science, **3** (11): 543. 1935.

[3] Metcalf, Z. P. *A Text-book of Economic Zoology*, p. 188. 1930.

Fried dishes like the foregoing are also prepared from *Parathelphusa,* but in this case the quantities of ingredients will do for as many as 30 of these smaller crabs.

Soup is generally made from *Parathelphusa* as follows:

> Crush 10 adult crabs without discarding either shell or gills. Boil for 15 minutes, after which add 2 teaspoons of pepper, ½ teaspoon of cumin, 1 teaspoon of peeled garlic, and 1 teaspoon of salt, and continue boiling for 20 to 30 minutes longer.

These crab dishes are considered of great medicinal value. Those of *Scylla* and *Neptunus* are used for convalescing malaria patients, also by asthma sufferers. The crab dish seems to act as a specific tonic. *Parathelphusa* soup is used for colds. The extensive use of crabs in such cases cannot be without some justification. In Indian medicine[4] crab curries are recommended for chronic fevers. There may be some mineral salts of medicinal value in the digestive glands of these animals or vitamins which are not destroyed in the cooking process. An investigation of the medicinal value of crabs as food appears to be indicated.

As our Indian crab fisheries have never been properly developed, there is great room for future expansion. The crustaceans fished throughout India perhaps outweigh both in quantity and value the yield of all other fisheries. Prawns rank first, with the crabs a good second. In 1923, crabs and prawns worth Rs. 135,056-14-0 ($33,764±) were sold in Madras.[5] The fishery statistics available for the west coast of the Presidency of Madras show that on an average about 500 maunds[6] of crabs worth Rs. 8,000 ($2,000±) are landed annually on the Malabar and South Kanara coast alone. In Bombay annually 80,000 crabs are caught and sold for Rs. 10,000 ($2,500±). In Bombay and Sind together, 500,000 crabs are caught and sold for approximately Rs. 30,000 ($7,500±) every year. In one year prawns and crabs fished along the Bombay coast sold for Rs. 2,500,000 ($625,000±). For Sind the figures are Rs. 1,500,000 ($375,000±). Large quantities are caught elsewhere in India, notably in Bengal.

If modern methods were employed and the crab and prawn fisheries properly developed, the industry would flourish. Only the Government of Madras has a modern department of fisheries which is giving some attention to the crab and prawn fisheries, but less than their importance warrants. The crabs are of such economic importance

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[4] Vastugunadipika. A Telugu Publication, 1914.

[5] MOSES, S. T. Bull. Madras Fisheries, **15** (6): 139. 1923.

[6] The maund, as generally used throughout India equals 82.284 pounds; in Madras, it sometimes may equal only about 25 pounds.

that Dr. B. N. Chopra's suggestions of the formation of an All-India Central Co-ordinating Organization for the Study of the scientific problems connected with our vast inland and coastal fisheries should receive earnest consideration by the Government.

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Harry S. Bernton, practicing physician and professor of hygiene and preventive medicine, Georgetown University, in recognition of contributions in the field of protein sensitization.

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Irvine T. Haig, principal silviculturist, U. S. Forest Service, in recognition of his contributions to forest research, particularly on the growth, yield, and natural reproduction of the Western White Pine of the Northwest.

Elmer Higgins, chief, Division of Scientific Inquiry, U. S. Bureau of Fisheries, in recognition of his contributions to marine biology as related to the fisheries.

Hugh Curtis McPhee, chief, Division of Animal Husbandry, Bureau of Animal Industry, in recognition of his contributions in the field of genetics of plants and animals.

Elmer Martin Nelson, principal chemist, Food and Drug Administration, in recognition of his researches in the field of nutrition and vitamins.

Walter Ramberg, physicist, National Bureau of Standards, in recognition of his contributions to mechanics, in particular his researches in the mechanics of structures.

Sanford Morris Rosenthal, senior pharmacologist, National Institute of Health, in recognition of his researches on the test for liver function, the pharmacology of arsphenamines and mercury, and the chemotherapy of sulfanilamide.

Harry Waltner Titus, senior biological chemist, Bureau of Animal Industry, in recognition of his contributions to the physiology and chemistry of nutrition, in particular the nutrition of poultry.

Everett Elmer Wehr, associate zoologist, Bureau of Animal Industry, in recognition of his contributions to helminthology, particularly nematode parasites of birds.

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GEOLOGY.—*Note on unreported Oligocene in Citrus County, Florida.*[1]

W. C. MANSFIELD, Geological Survey.

Mossom[2] in 1925 assigned to the Ocala limestone (upper Eocene) the entire thickness of about 115 feet exposed in the vertical face of the Crystal River Rock Company's quarry located five miles southeast of Crystal River, Citrus County, Florida. In 1929, Cooke and Mossom[3] also assigned to the Ocala limestone the entire thickness of the exposure, then about 121 feet. In 1937, the locality was visited by the writer and C. W. Mumm, and a collection of fossils was obtained from all parts of the opening (U. S. Geol. Survey station 14141). When studied later, this collection was found to contain a mixture of Oligocene and Eocene fossils. The quarry was visited in 1938 by the writer and F. S. MacNeil, and at this time a collection was obtained from the upper part of the face (station 14336). This collection contains definitely Oligocene fossils and supplies evidence for assignment of the upper part of the exposure to the Suwannee limestone.

Much of the wall of the quarry consists of limestone, but an undulating and somewhat indurated clayey band, one foot in thickness, runs irregularly across the upper part of the face, its position estimated to be in places 70 feet above the floor of the quarry. It clearly cuts across the horizontal beds of the underlying rock. The approximate lower boundary of this clay band is indicated by the dotted line on the accompanying photograph (Fig. 1), though on account of the nearly vertical exposure and concealment in places by rubble the exact position of the contact is not everywhere clear. This band is interpreted as the unconformable contact between the Ocala limestone (upper Eocene) and the overlying Suwannee limestone (Oligocene). The thickness of Oligocene strata may be as much as 30 feet.

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[1] Published with the permission of the Director, Geological Survey, United States Department of the Interior. Received Nov. 14, 1938.

[2] MOSSOM, STUART. *A preliminary report on the limestones and marls of Florida.* Florida State Geol. Survey 16th Ann. Rept. pp. 124, 125. 1925.

[3] COOKE, C. W., and MOSSOM, STUART. *Geology of Florida.* Florida Geol. Survey 20th Ann. Rept. p. 56. 1929.

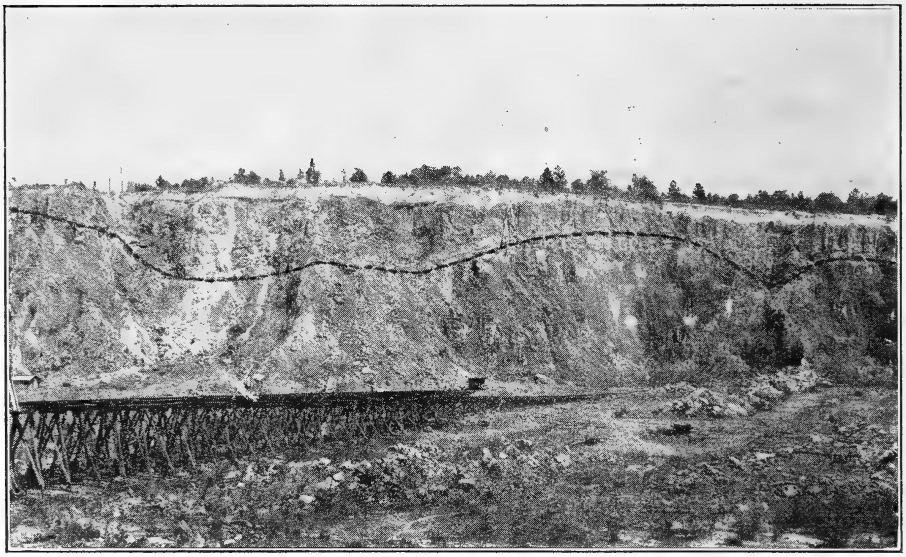

Fig. 1.—Face of Crystal River Rock Company's quarry, 5 miles southeast of Crystal River, Citrus County, Florida. Dotted line indicates unconformity separating Eocene and Oligocene beds.

Most of the fossils in the later collection (14336) came from a position above the undulating, horizontal band, and a few from rock believed to have fallen from the upper part of the quarry. The matrix in which the Oligocene fossils occur consists mainly of an indurated, semi-crystalline limestone. The following species were collected:

MOLLUSCA

Tubulostium sp. Two specimens were collected. This genus occurs in the Eocene. It also is living.

Pyrula sp., internal mold.

Cypraea sp., sculpture corroded.

Ampullina? sp.

Glycymeris? sp., internal mold.

Ostrea sp., apparently not an Eocene species.

Pecten brooksvillensis Mansfield?

Chione sp., similar to specimens in the Suwannee limestone (Oligocene) and in the lower bed at Ellaville, Florida (Oligocene).

Teredo? incrassata Gabb.

ECHINODERMATA

Rhyncolampus gouldii (Bouvé), quite common. This species is abundant in the Suwannee limestone (Oligocene).

FORAMINIFERA

The Foraminifera were examined by Dr. T. W. Vaughan who reports one determinable species. *Lepidocyclina supera* (Conrad), and concludes that the geologic horizon is Oligocene.

BOTANY.—*Some Georgia Discomycetes.*[1] Edith K. Cash, Bureau of Plant Industry. (Communicated by John A. Stevenson.)

The specimens here discussed were collected in Georgia in the spring of 1938 by Dr. Julian H. Miller. All except one are inconspicuous fungi growing on overwintered leaves. It is probable that some of these foliicolous species have a far wider distribution than is now known, but have hitherto escaped notice because of their small size. Specimens are in the herbarium of the University of Georgia, at Athens, and in the Mycological Collections of the Bureau of Plant Industry at Washington, and type material of the three species described as new has also been deposited in the Farlow Herbarium of Harvard University, and herbaria of the New York Botanical Garden and the University of Michigan.

1. **Lachnum corni** n. sp. (fig. 1.)

Apothecia stipitate, sparse, hypophyllous, soft fleshy, pilose, cupulate, avellaneous to wood brown (Ridgway),[2] 0.3–0.8 mm diam., hymenium whitish to pale olive buff, margin inrolled when dry, often folded triangularly; stem cylindrical, pilose, 0.5×0.1–0.2 mm; asci narrow-cylindrical, 8-spored, narrowed at the apex and gradually attenuated toward the base, 33–37.5×3–3.5μ; spores acicular, biseriate, hyaline, unicellular, 4–6×0.5–1μ; paraphyses lanceolate, extending beyond the asci, 50–55×3–3.5μ; exciple hyaline, pro-

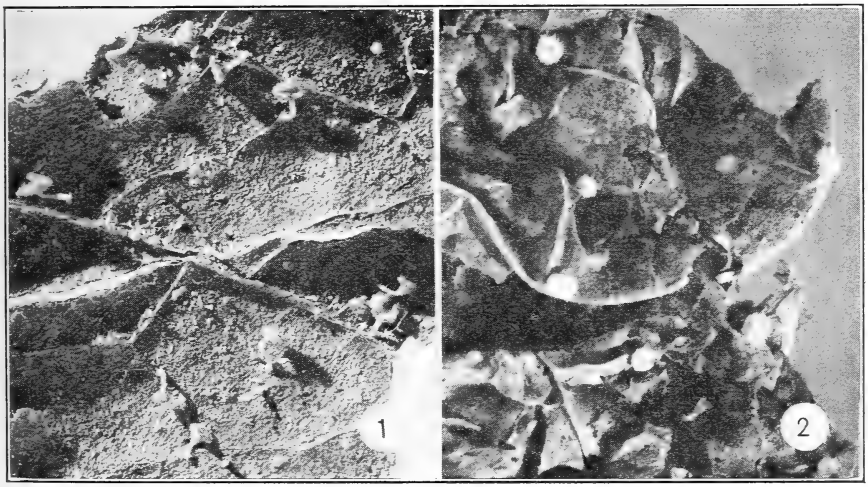

Fig. 1.—*Lachnum corni* on *Cornus amomum* (×6). Fig. 2.—*Lachnum halesiae* on *Halesia carolina* (×10). Photo. by M. L. F. Foubert.

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[1] Received November 14, 1938.

[2] Color terminology is that of Ridgway, *Color Standards and Color Nomenclature*, Washington, D.C., 1912.

senchymatous, covered, particularly at the margin, with brown, nonseptate, finely echinulate hairs, which are slightly swollen and paler at the apex, 50–65×2.5–3.5μ.

Apotheciis stipitatis, hypophyllis, molle carnosis, cupulatis, brunneopilosis, 0.3–0.8 mm diam.; hymenio albido-luteo; stipite cylindrico, 0.5×0.1–0.2 mm; ascis cylindricis, 33–37.5×3–3.5μ; ascosporis acicularibus, biseriatis, unicellularibus, hyalinis, 4–6×0.5–1μ; paraphysibus lanceolatis, 50–55×3–3.5μ; pilis brunneis, echinulatis, 50–65×2.5–3.5μ.

On leaves of *Cornus amomum*, Epps Bridge, Clarke Co., Ga., Apr. 24, 1938, J. H. Miller.

Lachnum crataegi var. *aristatum*, described by Velenovsky (7, p. 249) on branches of *Cornus* in Bohemia, has larger apothecia and longer asci and paraphyses. *Dasypezis corni-maris* v. Hoehn. (4, p. 4), which occurs on *Cornus* fruits in Europe, appears from the description to be a *Dasyscypha* in the strict sense, with filiform paraphyses; it differs from *L. corni* also in color and other characters.

2. **Lachnum halesiae** n. sp. (fig. 2.)

Apothecia scattered over the lower leaf surface, sessile or substipitate, soft fleshy, subglobose with the margin inrolled and the hymenium hidden, then expanded and patelliform, white tomentose, 0.2–0.6 mm diam.; hymenium translucent apricot-yellow (Ridgway), drying Capucine yellow; asci broad-cylindrical, short stipitate, broadly rounded at the apex, 8-spored, 47.5–50×7.5–8μ; spores obliquely uniseriate, hyaline, fusoid, guttulate, 12–15×1.5–2μ; paraphyses exceeding the asci, slender, lanceolate, septate, 65–80×2.5–4μ; hairs echinulate, hyaline, septate, not swollen at the apex, 90–130×3–4μ; exciple hyaline, prosenchymatous.

Apotheciis hypophyllis, sessilibus, molle carnosis, subglobosis dein patellaribus, albo-tomentosis, 0.2–0.6 mm diam.; hymenio flavo; ascis cylindricis, octosporis, 47.5–55×7.5–8.5μ; sporis hyalinis, fusoideis, 12–15×1.5–2.5μ; paraphysibus anguste lanceolatis, 65–80×2.5–4μ; pilis echinulatis, hyalinis, 90–130×3–4μ.

On leaves of *Halesia carolina*, west side of Mitchell Bridge, Athens, Ga., Mar. 20, 1938, J. H. Miller.

So far as is known, no species of *Lachnum* has been recorded on *Halesia* or on the other genera of the Styracaceae, and the fungus appears to be hitherto undescribed.

3. **Lachnum pollinarium** (Cke.) n. comb.

Peziza pollinaria Cke. Bull. Buffalo Soc. Nat. Sci. **2**: 292. 1875.

Trichopeziza pollinaria (Cke.) Sacc. Syll. Fung. **8**: 416. 1889.

On leaves of *Quercus montana*, Athens, Ga., Mar. 28, 1938, J. H. Miller.

The type specimen of *Peziza pollinaria* on oak leaves, New Jersey, *Ellis* 2158, was not available for study, but several specimens from the Ellis Herbarium, collected at Newfield, N. J., between 1875 and 1882, and labeled by Ellis as *P. pollinaria*, also *Ellis*, N. Am. Fungi 138 and *de Thümen*, Myc. Univ. 414, have been examined. The lanceolate paraphyses indicate that this species belongs to the genus *Lachnum*. Cooke (1, p. 292) described the hairs as white, but under the microscope they are pale brown.

4. **Dasyscypha acerina** (Cke. & Ell.) n. comb.

Peziza (*Dasyscypha*) *acerina* Cke. & Ell., Grev. **7**: 40. 1878.

Trichopeziza acerina (Cke. & Ell.) Sacc. Syll. Fung. **8**: 417. 1889.

On leaves of *Acer rubrum*, Lakemont, Ga., Apr. 23, 1938, J. H. Miller.

This agrees with the exsiccati specimen of Ellis, N. Am. Fungi 666, on leaves of *Acer* sp., Newfield, N. J.

5. DREPANOPEZIZA POPULI-ALBAE (Kleb.) Nannf.

On leaves of *Populus alba*, Agr. Campus, Athens, Ga., Mar. 30, 1938, J. H. Miller.

Although the conidial stage, *Marsonia castagnei* (Desm. & Mont.) Magn., has frequently been collected in the United States, the ascus stage has rarely been reported.

6. PYRENOPEZIZA FOLIICOLA (Karst.) Sacc.

On leaves of *Alnus rugosa*, Agr. Campus, Athens, Ga., Mar. 31, 1938, J. H. Miller.

No specimens of this species have been available for examination, and it has not been reported from North America, so far as is known, but since this Georgia specimen agrees with descriptions of *P. foliicola*, it is tentatively so named.

7. **Pyrenopeziza leucodermis** n. sp.

Apothecia hypophyllous, subepidermal, then superficial, sessile, scattered thickly over the leaf, at first nearly globose, then patellate, membranous-fleshy, pale brown, 150–250μ in diameter, 40–50μ deep; exterior furfuraceous, margin even or slightly fimbriate, inrolled when dry; hymenium subhyaline; asci clavate to narrow ellipsoid, 8-spored, narrowed at the apex and base, 28.6–35.2×5–6μ; spores obliquely uniseriate to biseriate, straight, cylindrical to clavate, hyaline, unicellular, guttulate, 5–7×0.7–1μ; paraphyses hyaline, filiform, unbranched, slightly enlarged and recurved at the tips, frequently indistinct and united in a hyaline mass; hypothecium hyaline, thin; cortex of thin-walled, pale brown cells, pseudoparenchymatous at the base, elongated at the margin and united in pointed clusters to form the fimbriate margin.

Apotheciis hypophyllis, sessilibus, subglobosis, dein patellatis, membranaceo-carnosis, pallide brunneis, furfuraceis, 150–250μ diam., 40–50μ altis; hymenio subhyalino; ascis clavatis, octosporis, 28.6–35.2×5–6μ; sporis cylindricis vel clavatis, hyalinis, unicellularibus, guttulatis, 5–7×0.7–1μ; paraphysibus hyalinis, filiformibus, apice recurvatis; hypothecio tenui, hyalino; excipulo pseudoparenchymatico, cellulis marginem versus elongatis.

On leaves of *Acer leucoderme*, Bobbin Mill, Athens, Ga., Apr. 27, 1938, J. H. Miller (type); of *Acer floridanum*, Savannah River, Elbert Co., Ga., May 2, 1938, J. H. Miller.

Pyrenopeziza aceris Nannf., which occurs on petioles of *Acer* in Europe, is a different fungus, with a clypeus-like covering and opening by a slit. A specimen of Desm. Pl. Crypt. Fr. 1423, issued as *Stictis atrata* Desm., and cited by Nannfeldt, (5, p. 141) has been studied.

Superficially this fungus on *Acer leucoderme* resembles an exsiccati specimen of Jaap, Fungi selecti exs. 556, issued as *Drepanopeziza campestris* (Rehm) Jaap, but differs in smaller asci and spores. It is possible that the Georgia fungus may belong to the genus *Drepanopeziza*. The two most essential characters of that genus, however, according to v. Hoehnel (3, p. 332) are the *Gloeosporium* conidial stage and the obconic ("kreiselformig") form of the apothecia, which have a narrow stem-like base deeply embedded in the tissues of the leaf. Since no *Gloeosporium* stage has so far been found in association with this discomycete, and the apothecia, even when young, are consistently subglobose, none showing the obconic or top-shaped form characteristic of *Drepanopeziza*, it is provisionally placed in *Pyrenopeziza*.

8. **Ionomidotis fulvo-tingens** (B. & C.) n. comb.

Cenangium fulvo-tingens B. & C., Grev. **4**: 4. 1875.

On wood of *Quercus alba*, Hulme Farm, Winterville, Ga., Mar. 26, 1938, J. H. Miller and G. Thompson.

The description of *Cenangium fulvo-tingens* B. & C. was based on a collection made by Michener in Pennsylvania, on dry wood of an unidentified host. One of the two specimens in the Michener Collection in Washington is labeled as on *Cornus*, in the other the host is not recorded. Both were collected in Chester Co., Pa., presumably by Michener, and a portion of at least one was examined by Curtis. A specimen of the same fungus, collected on bark of dead maple in Pennsylvania and examined by the writer, has recently been described by Overholts (6, p. 274). Both this Pennsylvania collection and that from Georgia appear to be specifically identical with the authentic specimens in the Michener Collection.

All of the species of Durand's genus *Ionomidotis* (2) are described as having a violet color reaction with KOH. Since the KOH reaction in all of the specimens of *Cenangium fulvo-tingens* examined is tawny or russet (Ridgway) rather than violet, a reference to this fungus to Durand's genus was at first not considered possible, in spite of its similarity in many respects to that genus. However examination of two species of *Ionomidotis* indicates that the violet color reaction with KOH is not constant. An authentic specimen of *Ionomidotis olivascens* Durand from the type locality, received through the courtesy of Dr. D. H. Linder, of the Farlow Herbarium, was found to show the same reddish brown color as *Cenangium fulvo-tingens*, when a portion of the apothecium was macerated in a solution of KOH, although Durand (2, p. 12) described it as "deep violet." Two specimens of *Ionomidotis irregularis* (Schw.) Durand were also tested in the same strength KOH solution. In a dried specimen from Bass Lake, Michigan, July 21, 1937, *A. H. Smith* 7636, received from the University of Michigan Herbarium, the color was deep violet, as described by Durand. A fresh collection from Port Republic, Md., K.D. Doak, Sept. 1938, gave a reddish brown reaction, although a microscopic mount in KOH showed a slight violet tinge. This variation in color reaction can not therefore be attributed to the length of time material has been kept, and further study will be required for its explanation.

Since *Cenangium fulvo-tingens* B. & C. shows the same reddish brown KOH reaction as some species of *Ionomidotis* and also agrees in its other essential characters, it may be considered to belong to that genus, if the generic concept is broadened to include species having a reddish-brown as well as a violet KOH reaction. Of the species listed by Durand, it is closest to *I. olivascens,* but differs from the latter in the smaller spores. The apothecia are described by Berkeley and Curtis as externally brownish-pulverulent; the specimens in the Michener Collection fail to show this character, which is most noticeable in the Pennsylvania collection made by Dr. Overholts.

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ICHTHYOLOGY.—*Twenty one new American gobies.*[1] Isaac Ginsburg, U. S. Bureau of Fisheries. (Communicated by Elmer Higgins.)

New species of gobiid fishes discovered as a result of an investigation of the American members of this difficult family carried out by me for the last few years, on and off, are here described. The following accounts consist chiefly of brief preliminary diagnoses. However, I revised the genera to which they belong, in manuscript, and the diagnoses state their most essential or key characters which are sufficient to distinguish the species; but of course, they are not adequate for a full understanding of their relationship to all the species within their respective genera. Especially important characters left out of these preliminary accounts refer to the lateral line organs. These structures have hitherto been neglected in accounts of American gobies; but they are of unusual scientific interest, and of great importance in the classification of gobies, especially in the delimitation of the genera and subgenera. However, it would perhaps be more

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[1] Published by permission of the U. S. Commissioner of Fisheries. Received December 9, 1938.

confusing than illuminating to describe these structures in fragmentary form and without illustrations. They will be considered later at some length and in systematic manner for all American gobies. Fuller accounts and a discussion of the relationship of the species will also be given in the generic revisions.

Special mention is made here of two very valuable collections which contributed the majority of the newly discovered species. One is a small but very important collection obtained by the Pawnee, of the Bingham Oceanographic Foundation, during 1925 and 1926, and submitted to me for study through the generosity of Professor Albert E. Parr. This collection, from the Atlantic and Pacific, contained eight new species, three of which I (1938, pp. 114, 119 and 120) have already described, while the other five are described here.

The other one is that obtained by Dr. Samuel F. Hildebrand in Panama as a result of and in connection with his study of the fauna of the locks of the Panama Canal during 1935 and 1937, at the time the locks were drained. This collection which Doctor Hildebrand very generously turned over to me for study, included seven undescribed species, one of which I (1938, p. 112) already described, and the other six are included here. This collection shows two things: first, the wealth of the gobiid fauna of the Isthmus of Panama, a region that has been comparatively well worked before, both in the number of species and their abundance; second, the industry, perseverance and ingenuity of Doctor Hildebrand in obtaining such an unusual collection. A large part of his success was due to the assiduous salvage of representative fishes left after the locks were drained, having obtained five new species then. However, the value of the collection is not to be gauged only by the new species discovered. The material obtained enabled me also to distinguish more accurately and draw up more adequate accounts of previously established species in my revisions of their genera. Doctor Hildebrand permits me to state that an important factor in his marked success was the use of poison in proper places in tide pools, chiefly those having a muddy or partly muddy bottom.

The numerical value of a given measurement is always expressed as a percentage of the standard length. The length of a specimen recorded refers to the total length, including the caudal fin, unless otherwise specified.

Lophogobius cristulatus, n. sp.

Nuchal crest low. Anterior boundary of scaled area on antedorsal extent in a nearly straight transverse line only a little behind eye. Depth 29, caudal 27.5, ventral 27, pectoral 25. D. 10, A. 9, P. 19, C. 15 (branched rays).

Holotype.—U. S. N. M. 107294. Pacific coast of Panama; S. F. Hildebrand. Male 74 mm. The original label was lost. It was probably collected on Farfan Beach near Balboa.

This appears to be the first record of a *Lophogobius* from the Pacific coast of America. The specimen examined represents a species distinct from the common *L. cyprinoides* of the Atlantic, differing in having the nuchal crest strikingly lower, and the antedorsal distance completely covered with scales, except for a narrow transverse area behind the eye. The proportions of the depth and fins of the single specimen examined have lower numerical values than specimens of *cyprinoides* of similar size. The caudal has 15 branched rays, while in 55 specimens of *cyprinoides* counted, only 2 had 15 rays, the preponderant majority having 14.

Lythrypnus heterochroma, n. sp.

D. 10, A. 9, P. 15. Scales very large, 22, the anterior most ones situated on a vertical through base of third dorsal spine. Six transverse bands under first dorsal, two longitudinal bands on posterior part of body.

Holotype.—Bingham Oceanographic Collection 375. Glover Reef, off the coast of Yucatan, Mexico. Male 22 mm.

Of all the known American gobies this species is structurally nearest to (*Gobius*) *Lythrypnus mowbrayi* (Bean), but the two species are probably of comparatively remote relationship, their divergence being of at least subgeneric magnitude. This question will be considered at some future time. It will suffice to state here that *heterochroma* differs from *mowbrayi* in having larger scales. It further differs from *mowbrayi,* as well as from all known American gobies, in having a fairly well marked diphasic color pattern, transversely banded anteriorly, longitudinally banded posteriorly.

Lythrypnus dalli (Gilbert)

Restriction of the name dalli.—Having revised the genus *Lythrypnus* it became apparent that the gobies hitherto designated as *dalli* in the literature, including Gilbert's original material, belong to at least two species. Gilbert did not designate a holotype, and it becomes necessary to definitely restrict the application of the name *dalli* in order to supply both species with names.

I examined five specimens of what appears to be Gilbert's original material, two in the Bureau of Fisheries and three in the National Museum, labeled *Gobius dalli.* All five specimens are in bad condition. They are faded and the fins are broken, while the color and the relative length of the spines and rays are, in general, of importance in properly distinguishing the species of *Lythrypnus.* They are thus poorly adapted for study in distinguishing species; but our final decision regarding the status of the name *dalli* must be based on their study, and the pertinent characters that may be deciphered are stated.

The two specimens in the Bureau of Fisheries, from Albatross station 3001, are in worst condition. They are entirely faded and the fin rays cannot be counted with assurance. As near as I can determine, the counts are D. 16, A. 13. They apparently belong to *dalli* as here restricted.

The three specimens in the National Museum are in two jars, having different museum numbers, but both bearing the red type label. Jar 48255 contains two specimens, from Albatross station 3001 in the Gulf of California, 14 and 17 mm in standard length, having D. 16, A. 13, P. 18, and D. 18, A. 14, P. 18, respectively. Traces left of the cross bands are of approximately the same width as in 18 other specimens examined, in good condition, also from the Gulf of California, that will be described in a revision of the genus. These two specimens are apparently conspecific with the other 18, and the smaller one is here formally designated as the lectotype.

Jar 41974 contains one specimen, from Catalina Island, 27 mm in standard length, having D. 18, A. 15, P. 19. In the fin ray counts it more nearly agrees with the following species, *latifascia*. Traces left of the bands are appreciably narrower than in the two more recently preserved specimens of *latifascia* examined, and are more nearly like in *dalli* as here restricted, but their narrow appearance is probably due to fading. Very probably this specimen is an example of *latifascia*, unless still another closely related species exists at Catalina Island.

Lectotype.—U. S. N. M. 107287. Gulf of California, Albatross station 3001, lat. 24° 55′ 15″, long. 110° 39′; 33 fathoms; March 16, 1889; 14 mm in standard length.

Lythrypnus latifascia, n. sp.

D. 18, A. 14–15, P. 18–19. Tip of longest dorsal spine reaching base of sixth dorsal ray in female. Dark cross bands wide.

Holotype.—U. S. N. M. 107282. Fishermen's Cove, Catalina Island, California; Vernon Brock; June 25, 1935; female 22 mm in standard length.

This species differs from *dalli*, as restricted above, in having strikingly wider cross bands. Color differences in the genus *Lythrypnus*, in general, are so striking and fairly constant, that they must be considered as of specific importance, on a par with structural differences in other genera, as I will discuss fully in the revision of the genus. Judged by the two specimens examined, *latifascia* has average higher counts of the fin rays, and the spines in the female at least, are longer than in *dalli*.

Lythrypnus crinitus, n. sp.

D. 17, A. 13, P. 19. Longest dorsal spine reaching end of second dorsal in male. Cross bands on body obsolescent, only very feeble traces of such bands discernible.

Holotype.—U. S. N. M. 107281. Albemarle Island, Galapagos Archipelago; 32 fathoms; W. L. Schmitt; January 25, 1934; male 30 mm.

This species fairly well agrees in its important structural characters with *dalli;* the differences in the specimens examined are of a minor nature. It differs from *dalli* chiefly in color, lacking the striking cross bands present in that species. It is a markedly pale species, unlike all its congeners which have the color pattern strikingly developed and beautiful.

Microgobius emblematicus (Jordan and Gilbert)

Restriction of the name emblematicus.—Before the following species may be supplied with a name, it becomes necessary to definitely restrict the use of the older name *emblematicus*. The types on which that name has been based appear to have been lost, while the original description is more or less applicable to three distinct species that occur in the type locality. It is very probable that the authors of *emblematicus* had a mixture of the three species, since all three are common and they failed to take proper account of their distinguishing characters.

The paper in which *emblematicus* was established (Jordan and Gilbert, 1882, p. 330) consists of descriptions of the new species contained in a collection made for the National Museum, and the types presumably should have been deposited in that museum. However, they are not present on the shelves and no record was found in the register or card catalog of the museum to indicate that the types ever reached there. Furthermore, in the paper referred to, the authors give museum numbers for all the other species described there, with the sole exception of *emblematicus*. It seems apparent, therefore, that the types were lost, and failed to reach the museum. They are probably not now in existence, and we must rely entirely on the authors' account to determine the status of the name *emblematicus*.

Outside of the description of life colors which I have no means of checking at present, the only pertinent statements in the original description that may throw some light on the question as to which species the authors had, are as follows: "Dorsal spines very slender and weak, some of the middle ones usually prolonged, sometimes nearly reaching to base of caudal, sometimes little elevated . . . D. VII–16; A. 17." The words "sometimes reaching nearly to base of caudal" shows that the authors had some specimens at least of that species to which the name *emblematicus* is here restricted; the rest of the above quoted statement refers to females of the same species and equally as well to the species described below as *brevispinis* or to *M. tabogensis* Meek and Hildebrand (1928, p. 873). The count of the second dorsal refers only to *emblematicus*, as here restricted, according to my determination of the frequency distributions of the three species. The anal count refers to the same species and to *tabogensis* as well, but not to *brevispinis*. However, the differences between the predominant numbers of the two counts among the three species is only one ray, and hence the counts are not of decisive importance in this connection. It may be concluded then that the original account was based certainly on some specimens of *emblematicus* as restricted below, and quite probably also on specimens of one or both the other species. The question now is whether later authors restricted the use of the name *emblematicus*.

That name was used in connection with actual specimens in two later works. Gilbert and Starks (1904, p. 174) had specimens of at least two of the species which they recorded under the one name, *emblematicus*. I examined a lot of only 5 of their specimens and found it to consist of a mixture of two species. Consequently, they cannot be said to have restricted the use of that name. The next authors who treated of the species concerned are Meek and Hildebrand (1928, pp. 871–874). They definitely distinguished *tabogensis*. Furthermore, I examined part of their material which they included under their account of *emblematicus*, the part deposited in the National Museum, and find that all those specimens belong to that species here described as *breivspinis*. Nevertheless, it cannot be said that these authors thus restricted the use of the name *emblematicus* to that species. They did not state so definitely and they apparently did not suspect that the name *emblematicus* was possibly based on more than one species.

Since this was not done by previous authors, the name *emblematicus* is herewith restricted by the formal designation of a neotype. As here restricted, *emblematicus* differs from *brevispinis* chiefly in the extent of the squamation, the number of fin rays, and the relative length of the dorsal spines and ventral fin of the male. *M. tabogensis* differs from both chiefly in having a patch of modified, ctenoid scales at some distance behind the base of the pectoral fin. The restriction as made seems to be best on a consideration of all the points involved. It saves Meek and Hildebrand's *tabogensis* as a valid name, and we know for certain that the original authors had some specimens of the species to which the name is restricted. The name *emblematicus* itself applies to the species restricted more than to the other two.

Neotype.—Stanford University Collection 33208. Panama Bay; C. H. Gilbert; male 39 mm in standard length.

Microgobius brevispinis, n. sp.

Mouth oblique, end of maxillary falling under middle of eye to under posterior margin of pupil. Scales 62–72, all cycloid; bare area on back under first dorsal comparatively restricted. Predorsal fold moderate. Tip of longest spine reaching base of second to fourth ray in male, a little short of origin of second dorsal in female. D. 17–18, A. 18–19, P. 22–23. Ventral approximately reaching origin of anal in male, falling considerably short in female. A spot or band below first dorsal absent or very faint.

Holotype.—U. S. N. M. 81842. Balboa, Panama; in tide pools; Meek and Hildebrand; February 7, 1912; male 42 mm in standard length.

This species is nearest to *emblematicus* as restricted above where their distinguishing characters are indicated.

Microgobius curtus, n. sp.

Mouth moderately oblique, end of maxillary under middle of eye or a little short of that point. Scales 62–70, cycloid, except a small patch of rather weakly spinuliferous scales at middle of body under first dorsal; bare area on back under first dorsal moderate. Predorsal fold very low to nearly obsolescent. Tip of longest spine reaching base of eighth to fifteenth ray. D. 16, A. 16, P. 21–22.

Holotype.—U. S. N. M. 107292. Salada, Guayaquil, Ecuador; in mangrove swamp; October 1–2, 1926; W. L. Schmitt; male 30 mm in standard length.

Structurally this species is nearest to *M. tabogensis* Meek and Hildebrand. It differs in having smaller scales, fewer fin rays, and longer spines in the female especially.

Parrella macropteryx, n. sp.

Scales about 28–29, present on antedorsal distance. Maxillary rather long, its posterior end on a vertical at some distance behind eye in large male. Tip of longest spine reaching base of tenth ray. D. 13, A. 12. P. 16–18. Pectoral unusually long, its tip reaching to under base of seventh or eighth dorsal ray. Head subterete, interorbital narrow. Pectoral 44–45, caudal 60, depth 18.5–19.5, depth of caudal peduncle 11–11.5, maxillary in male 15.5–17. A series of five diffuse blotches on body.

Holotype.—Bingham Oceanographic Collection 1688. Siguanea Bay, Isle of Pines, Cuba; taken by the Pawnee with a trawl; April 6, 1925; male 55 mm.

This species differs from *Parrella maxillaris*, the only other known species of its genus, in having scales on the antedorsal area, a shorter maxillary, more numerous rays in dorsal and anal, fewer pectoral rays, a longer pectoral and caudal, longer dorsal spines, and having the body not as slender. It may be distinguished from all known American gobies by its extremely long pectoral.

Parrella spilopteryx, n. sp.

Scales 34, present on antedorsal distance. End of maxillary under middle of eye in male. Tip of longest dorsal spine falling short of origin of second dorsal. D. 12, A. 12, P. 21. Pectoral of moderate length reaching a vertical through base of third dorsal ray. Head somewhat depressed; interorbital wide. Pectoral 31.5, caudal 42.5, depth 21.5, depth of caudal peduncle 10.5, maxillary 12. Body with four, diffuse, rather wide cross bands; a black spot on base of pectoral near its upper margin.

Holotype.—U. S. N. M. 107293. Miraflores Locks, Panama Canal; upper chamber, east side; S. F. Hildebrand; April 28, 1937; male 74 mm, the only specimen examined.

This species is evidently widely divergent from both *P. maxillaris* and *P. macropteryx*. It differs from both in having a notably shorter maxillary, depressed head and wide interorbital.

Parrella fusca, n. sp.

Scales about 38, present on antedorsal distance. Maxillary ending under middle of eye. Tip of longest dorsal spine failing to reach origin of second dorsal. D. 13, A. 13. P. 20. Head depressed, interorbital rather wide. Caudal 38.5, depth 20, depth of caudal peduncle 8, maxillary 10. Color nearly uniform, dark brown, shaded with lighter color.

Holotype.—U. S. N. M. 107295. Miraflores Locks, Panama Canal, lower chamber; S. F. Hildebrand; March, 1937; female 42 mm, the only specimen examined.

This species is nearest structurally to *spilopteryx*, but is evidently widely divergent from it. They diverge chiefly in the lateral line organs. Without considering the lateral line organs for the present, the two species are separable by their color, and by *fusea* having a more slender caudal peduncle and more numerous dorsal and anal rays.

The three new species of *Parrella* here described, together with the hitherto only known genotype, constitute a rather heterogeneous group. However, although the four species are rather widely divergent, they are apparently nearer to one another than any one of them is to other gobies, and they are properly grouped in one genus. Furthermore, the genus *Parrella* as now constituted bridges the gap, in some important respects, between *Microgobius* and *Bollmannia*. A full discussion of the proper boundaries of these three genera, and their relationship, involves a consideration of the relationship of the contained species, respectively, and would take up too much space. This discussion is reserved for a later paper.

Bollmannia chlamydes Jordan

Restriction of the name chlamydes.—It is necessary to definitely restrict the application of the name *chlamydes*, because Jordan's account is based on at least two species, possibly more. Most of Jordan's specimens, judged by the material now preserved in the National Museum, belonged to *chlamydes*, as restricted below. The number of fin rays given in the original description refers to this species; but the color description is undoubtedly based in part on the following species, *umbrosa*, and at least one of the six specimens on which I base that species have been separated from presumably Jordan's original material. These two species are very markedly distinct, and a study of their lateral line organs shows that the divergence between them is of subgeneric magnitude. In spite of their wide divergence, specimens of both species were included in the original description of *chlamydes*. Jordan also states: "Middle caudal rays very long, somewhat more than half length of body." This statement agrees and nearly agrees with the two species here described as *longipinnis* and *pawneea*, respectively. The caudal in the specimens examined of *chlamydes*, as here restricted, is broken. In one specimen in which it appears to be nearly entire, it is about one-third the standard length. Since the caudal length is of specific importance among the species of *Bollmannia*, it is very possible that one or two still other species were included in the original account of *chlamydes*.

The question now comes up, did Jordan restrict his species by designating a particular specimen as the type? Seemingly he did so, since the original description states the type to be U. S. N. M. 41158, and its length is given as $4\frac{3}{4}$ inches. However, the type specimen cannot now be identified with certainty, as follows.

U. S. N. M. 41158, presumably the type, is entered on the register as having been obtained at Albatross station 2804, whereas only two stations are mentioned in the original description, 2800 and 2805. Furthermore, jar 41158 now contains two specimens (belonging to two distinct species), while Jordan definitely designated a single specimen as the type and stated its length in the original description. To add further to the tangle it is to be noted that numbers 41142, 41234, 41461 and 41489 were also entered in the museum register as being the "type" of the species. Number 41158 now bears the red type label but it was probably attached at some later time, since numbers 41142 and 41489 containing a single specimen each, formerly bore red labels which are now placed within the jars. It is apparent, therefore, that some error has been committed. Either the museum number or the Albatross station numbers as given in the original description are erroneous. It is also possible that the type specimen after having been studied was never set aside definitely or that it was later mixed with other specimens.

In view of these uncertainties and the necessity of definitely restricting the name *chlamydes*, one out of three specimens in U. S. N. M. 41234, from Albatross station 2800, is hereby designated as the lectotype. The lot of three specimens was originally entered on the register as "types." Of the two specimens in 41158, the larger one, a female 82 mm in standard length, also belongs to this species (the smaller one now designated as U. S. N. M. 107288 is an *umbrosa*). Consequently the present restriction of *chlamydes* will stand even if we assume that 41158 is the true type.

Lectotype.—U. S. N. M. 93825. Panama Bay; Albatross station 2800, lat. 8° 51′, long. 79° 31′ 30″; 7 fathoms; March 30, 1888; male 75 mm in standard length.

Bollmannia umbrosa, n. sp.

Dorsal and anal rays usually 13 and 14, respectively, sometimes 12 and 13, respectively. Pectoral rays 24–26. A lengthwise row of large scales at lower margin of cheek in addition to other scales; approximately upper third of opercle covered with 3 or 4 rather large scales. Tip of longest dorsal spine reaching base of third to fifth ray in large females. Head 30–32, eye 8.5–9, depth of caudal peduncle 10–11. Body with 8–10 faint cross bands; first dorsal with a black blotch; upper lip with a black marginal band.

Holotype.—U. S. N. M. 107290. Panama Bay; Albatross station 2804, lat. 8° 16′ 30″, long. 79° 37′ 45″; 47 fathoms; March 30, 1888; male 70 mm in standard length. Removed from U. S. N. M. 41395, containing in addition 4 specimens of *B. chlamydes* as restricted above.

This species is closely related to *B. macropoma* Gilbert, differing in having a smaller eye, somewhat deeper caudal peduncle, somewhat longer dorsal spines, and more numerous cross bars on the body.

Bollmannia marginalis, n. sp.

D. 14–15, A. 14–15, P. 24–25. Row of scales at lower margin of cheek absent; upper third of opercle covered with large scales. Tip of longest dorsal spine in male reaching to middle of second dorsal base and as far as middle of caudal peduncle. Head 27.5–28.5, caudal 36.5–39, eye 8.5–9.5, depth of caudal peduncle 9.5–11. Body with a median row of five black blotches; first dorsal with a black spot at its margin; no black band on upper lip.

Holotype.—U. S. N. M. 107284. Solango Island, Ecuador; 12 fathoms; W. L. Schmitt; January 18, 1935; male 56 mm.

Judged by the lateral line organs this species is nearest to *B. litura* from the Atlantic, differing strikingly in having more numerous fin rays, a shorter head and caudal, a smaller eye, and a more slender caudal peduncle. The combination of a short caudal and long dorsal spines is distinctive. It differs from all its congeners in having the dorsal spot located at the margin of the fin.

Bollmannia ocellata Gilbert

Restriction of the name ocellata.—The National Museum does not have any specimen or a jar of specimens of *ocellata,* which is labeled as the type, and there is no record of such a type ever having been present. Apparently no type of this species has ever been set aside. From Gilbert's original description one gathers that most of his specimens had comparatively long spines while some had rather short ones. In my revision of the genus I have distinguished in manuscript three closely related species from the Gulf of California, which differ, in part, according to the length of the spines, and it seems possible that Gilbert included two or all three of these species under his account of *ocellata.* At any rate, the original account applies to a mixture of these three species. It therefore becomes necessary, in order to supply all three species with names, to restrict the name *ocellata* to one of these species and designate a lectotype. The original description was based on "numerous specimens" from Albatross stations 3031 and 3035. The National Museum now has but three lots of specimens labeled "Bollmannia ocellata," only one of the lots, U. S. N. M. 46695, from the type localities, from station 3031.

No other specimens from the two original stations are present in either the Bureau of Fisheries or the National Museum. I am, therefore, constrained to restrict *ocellata* to this lot and designate one of the specimens as the lectotype, although the specimens are not in good condition and most of Gilbert's specimens possibly did not belong to this species. Strictly speaking the specimen selected may not be a lectotype, since it is not certain that the lot of specimens under consideration were examined by Gilbert when he established his *ocellata.* If this lot was not included in Gilbert's original material, such material may not be in existence now, and the specimen here selected is properly a neotype. Whatever the type is to be called, the name *ocellata* is herewith formally restricted to the species represented by the type selected.

Lectotype.—U. S. N. M. 107286. Off Bay Adair, Gulf of California; Albatross station 3031; lat. 31° 6′ 45″, long. 114° 28′ 15″; 33 fathoms; March 27, 1889; female 76 mm. Removed from U. S. N. M. 46695 containing 7 other specimens of the same species.

Bollmannia pawneea, n. sp.

Dorsal and anal rays usually 14, sometimes 13. Pectoral rays 23–25. Row of scales at lower margin of cheek absent; opercle with 4 or 5 large scales almost entirely covering upper half. Tip of longest dorsal spines in male reaching a point between base of twelfth ray and middle of caudal peduncle. Head 29–32, caudal 37–43, depth of caudal peduncle 11–13. First dorsal with a black spot, no other distinctive color marks on head and body.

Holotype.—Bingham Oceanographic Collection 1689. Perlas Islands, Panama Bay, lat. 8° 29′ 40″, long. 78° 52′ 30″; 19–24 fathoms; collected by the Pawnee; March 31, 1926; female 93 mm.

Specimens of this species were also examined from the Gulf of California. This species is apparently near to *ocellata* as restricted above, differing in having longer dorsal spines and a deeper caudal peduncle. This species is especially characterized by a great profusion of cutaneous papillae.

Bollmannia longipinnis, n. sp.

D. 14, A. 14, P. 22–23. Row of scales at lower margin of cheek absent; opercle with 2 or 3 scales of moderate size at upper anterior corner. Tip of longest dorsal spine in male reaching beyond base of caudal, somewhat shorter in female. Head 29–30, caudal 50–68, depth of caudal peduncle 11.5–12.5. First dorsal with a black spot, no other distinctive color marks on head and body.

Holotype.—Bingham Oceanographic Collection 1690. Angeles Bay, Gulf of California; collected by the Pawnee; May 13, 1926; male 127 mm.

This is a well marked species, and is saliently characterized by the combination of excessively long spines, a long caudal, and a reduced squamation on the opercle. Its nearest relatives seem to be *pawneea* and *ocellata.*

Risor mirus, n. sp.

D. 11, A. 9, P. 17. Ventral attaining origin of anal or slightly beyond. Maxillary ending under anterior margin of pupil.

Holotype.—Bingham Oceanographic Collection 1691. Siguanea Bay, Isle of Pines, Cuba; trawl; collected by the Pawnee; April 6, 1925; male 22 mm.

This species differs from the two known species of its genus, *R. binghami* (Parr) and *R. ruber* (Rosen), by a combination of three characters, namely, having one or two rays less in the dorsal, a longer ventral and a shorter maxillary. It further differs from *binghami* in having two mucous pores, instead of one, on the interorbital space.

The peculiar and unusual structure of the head and especially that of the lips and dentition were originally used by me in establishing *Risor* (1933, p. 56). At the time of its establishment I had only one specimen for study and *Risor* was therefore placed as a subgenus of *Garmannia* to which the species were assigned by previous authors, pending the study of more specimens in order to gain some knowledge in regard to the variability of these characters. I have now studied 6 more specimens. The striking characters on the basis of which *Risor* was originally established prove to be fairly constant and peculiar to the three species examined. These characters indicate a very high degree of divergence, and *Risor* is, therefore, recognized as a distinct genus.

Enypnias aceras, n. sp.

Scales 41–46, not embedded, those on posterior part of body and caudal peduncle ctenoid. No flaps on top of snout. Dorsal rays 14. Body with a cross-banded color pattern well or fairly marked; no well marked spot at base of pectoral.

Holotype.—U. S. N. M. 107298. Miraflores Locks, Panama Canal, lower chamber; S. F. Hildebrand; March 1937; male 41 mm.

It is an easy matter to distinguish this species from *E. seminudus* (Günther), the only other known species of its genus, by the larger, non-embedded, ctenoid scales, the absence of flaps on snout, and the banded color pattern.

Garmannia hildebrandi, n. sp.

Scales 25–30, extending forward to a vertical approximately through origin of first dorsal; anterior bare area at dorsal and ventral profile extensive; usually 4 scales in caudal row, sometimes 5 or 6. First dorsal spine prolonged in male. D. 11, A. 10–11, P. 16–18. Head subterete. Maxillary ending under posterior margin of pupil in male, slightly short of that in female. Depth of caudal peduncle 13–15. Diffusely cross-banded color pattern.

Holotype.—U. S. N. M. 107297. Gatun Locks, Panama Canal, upper chamber; S. F. Hildebrand; February 21, 1935; male 35 mm.

Doctor Hildebrand obtained 25 other specimens with the type, and it is evidently a common species. This species is of much interest from the point of view of geographic distribution. In 1937 Doctor Hildebrand also obtained 4 specimens in the Pedro Miguel Locks. This is the only gobiid that has been found so far on the Atlantic and Pacific sides of the Isthmus of Panama. But whether it existed on both sides before the canal was opened remains unknown.

This species is near structurally to (*Gobius*) *Garmannia chiquita* (Jenkins and Evermann), differing in the subterete head and in having the anterior bare areas at the dorsal and ventral profiles more extensive. The scales in the caudal row are usually 4, instead of 6, and the number of pectoral rays is less, but there is a certain degree of intergradation in these characters. The most striking difference between them is found in the lateral line organs.

I take pleasure in naming this common and interesting species after my colleague in the Bureau of Fisheries and its efficient collector, Dr. Samuel F. Hildebrand.

Garmannia spilota, n. sp.

Scales 29, extending to a vertical a little in front of origin of first dorsal, anterior bare area at dorsal and ventral profile moderate; 4 scales in caudal row. First spine not prolonged. D. 11, A. 10, P. 19. Head depressed. Maxillary ending under posterior margin of pupil. Depth of caudal peduncle 16.5. Body not banded, nearly uniformly colored, with a longitudinal median row of spots.

Holotype.—U. S. N. M. 81828. Colon, Panama; in tide pools; Meek and Hildebrand; March 12, 1912; male 24 mm.

This species is nearest to *hildebrandi;* differing in having a deeper caudal peduncle, more numerous pectoral rays, the bare areas in front less extensive and in color.

Garmannia spes, n. sp.

Scales extending forward to a point under base of second to fourth dorsal ray; two isolated, large, ctenoid scales, one behind the other, at a short distance behind base of pectoral, near midline. D. 11–12, A. 10, P. 16. Head depressed. Maxillary ending under middle of eye. Depth of caudal peduncle 12. Body diffusely and very irregularly cross-banded.

Holotype.—U. S. N. M. 107299. Drydock, Mt. Hope, Canal Zone; J. B. Shropshire; February 18, 1937; female 20 mm.

This species seems to be most nearly related to *G. paradoxa* (Günther), apparently being the Atlantic coast counterpart of that Pacific coast species. The extent of squamation is the same as in *paradoxa* and it has the two isolated scales behind the pectoral which is characteristic of that species. It differs in having fewer pectoral rays.

Garmannia homochroma, n. sp.

Scales 28–31, anteriormost scales on a vertical near base of pectoral; anterior bare areas moderate; usually 4 scales in caudal row, sometimes 5 or 6. First dorsal spine in male not prolonged. D. 11–12. A. 10, P. 18–20. A small barbule below anterior nostril. Head markedly depressed. Maxillary notably long, extending to a vertical behind eye in male. Depth of caudal peduncle 12.5–16. Body nearly uniformly and very moderately dusky, only very faint traces of cross bands when viewed from dorsal aspect.

Holotype.—U. S. N. M. 107296. Pedro Miguel Locks, Panama Canal; S. F. Hildebrand; February 20, 1937; male 25.5 mm in standard length.

In addition to well marked differences in the lateral line organs, this species differs from all its other congeners, by the following combination of characters: the presence of a barbule, a very long maxillary, a notably depressed head. On account of the very distinctive combination of all characters, its immediate relationship is not patent. Its nearest relatives are possibly *spilota* or *chiquita*, but the divergence is wide.

Garmannia pallens, n. sp.

Scales 9–12, extending forward to a point under bases of sixth to eighth dorsal rays; 4 scales in caudal row. First spine of male prolonged. D. 11, A. 9, P. 15–16. Head compressed. End of maxillary in male reaching a point under posterior margin of eye. Light yellowish, crossed by 13–14 narrow, dark bands.

Holotype.—U. S. N. M. 107327. Barahona Harbor, Santo Domingo; in 2–4 feet; rocky bottom; John C. Armstrong; July 9, 1933; male 15 mm.

This species is nearest to *G. macrodon* (Beebe and Tee-Van), differing in a notably greater extent of squamation, fewer fin rays, and a paler color.

Gobulus myersi, n. sp.

D. 11, A. 10, P. 15. Head 30.5, depth of head 14, depth 18, depth of caudal peduncle 10.5. Ventral aspect darker than dorsal aspect.

Holotype.—U. S. N. M. 107283. Gulf of Mexico, off Cape Sable; Albatross station 2374, lat. 29° 11′ 30″, long, 85° 29′; 26 fathoms; February 7, 1885; male 27 mm.

This is the first species of its genus now to be made known from the east coast. It is evidently nearest to *G. crescentalis* (Gilbert), from the Gulf of California, differing in having a deeper body and head, and one or two fewer rays in the pectoral.

It is a pleasure to name this species after Professor George S. Myers of Stanford University, who discovered and salvaged the type from a lot of neglected, unidentified, miscellaneous material while he was in charge of the Division of Fishes in the National Museum.

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ZOOLOGY.—*North American monogenetic trematodes. III. The family Capsalidae (Capsaloidea).*[1] EMMETT W. PRICE, U. S. Bureau of Animal Industry.

This paper is the third of a series on the North American mono-

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[1] Received November 19, 1938.

genetic trematodes and deals only with the family Capsalidae; it also completes the general consideration of the suborder Monopisthocotylea Odhner. The organization and purpose of this paper are the same as for parts I and II (Price 1937, 1938).

Family CAPSALIDAE Baird, 1853

Synonyms.—Phyllinidae Johnston, 1846; Tristomidae Cobbold, 1877; Tristomatidae Gamble, 1896; Encotyllabidae Monticelli, 1888.

Diagnosis.—Body elliptical, oval or cordate, flattened. Cuticula smooth or provided with papilliform projections, sometimes with spines along lateral margins of dorsal surface. Anterior portion of body constricted, forming a cephalic lobe. Anterior haptors in form of a pair of suckers, or of glandular areas, or both. Posterior haptor disc-like or sucker-like, armed with 1 to 3 pairs of large hooks and 14 marginal hooklets. Oral aperture ventral, never surrounded by an oral sucker; pharynx well developed; intestine usually with median and lateral dendritic diverticula. Special sense organs consisting of a pair of papillae at anterior margin of cephalic lobe and of 2 pairs of eyes. Excretory apertures dorso-lateral, at or near level of pharynx. Male and female genital apertures separate, or opening into a common genital atrium, usually lateral. Testes 2 or more. Ovary median, pretesticular. Vagina present or absent.

Type genus.—*Capsala* Bosc, 1811.

KEY TO SUBFAMILIES OF CAPSALIDAE

1\. Posterior haptor with septa..........2
    Posterior haptor without septa..........3
2\. Two testes..........Trochopinae Price
    Numerous testes..........Capsalinae Johnston
3\. Two testes..........Benedeniinae Johnston
    Numerous testes..........Nitzschiinae Johnston

Subfamily BENEDENIINAE Johnston, 1931

Synonyms.—Encotyllabinae Monticelli, 1892; Ancyrocotylinae Monticelli, 1903.

Diagnosis.—Anterior haptors in form of suckers or glandular areas, or both; posterior haptor sucker-like, subsessile or pedunculated, without septa, armed with 2 to 3 pairs of hooks and 14 marginal hooklets. Testes 2 or, rarely, 1. Ovary entire. Vagina present or absent.

Type genus.—*Benedenia* Diesing, 1858.

KEY TO GENERA OF BENEDENIINAE

1\. Lateral margins of body inrolled ventrally..........*Encotyllabe* Diesing
    Lateral margins of body not inrolled ventrally..........2
2\. Intestinal tract consisting of simple unbranched ceca..........*Ancyrocotyle* Parona and Monticelli
    Intestinal tract consisting of ceca with dendritic lateral and median branches..........3
3\. Anterior haptors consisting of glandular areas only. *Entobdella* Blainville

Anterior haptors consisting of suckers, or of both glandular areas and suckers 4

4. Anterior haptors consisting of suckers . . . . *Benedenia* Diesing

Anterior haptors consisting of both suckers and glandular areas . . . . *Pseudobenedenia* Johnston

Genus BENEDENIA Diesing, 1858

Synonyms.—*Epibdella* Beneden, 1856, in part; *Phylline* Oken, 1815, not Abildgaard, 1790, in part; *Tristoma* Cuvier, 1817, in part.

Diagnosis.—Anterior haptors in form of suckers or sucker-like discs; posterior haptor sucker-like, without septa, armed with 3 pairs of dissimilar hooks and 14 marginal hooklets. Testes 2, with zones coinciding and fields separate or touching. Vas deferens usually not forming preovarial loop. Ovary immediately pretesticular, not separated from testes by wide band of vitelline follicles. Vagina present or absent.

Type species.—*Benedenia elegans* Diesing, 1858 (=*Epibdella sciaenae* Beneden, 1856, renamed).

Johnston (1929) proposed a division of the genus *Benedenia* into 3 subgenera, *Benedenia*, *Parabenedenia* and *Benedeniella*, but since "the position of the vaginal aperture in relation to the common genital duct" is the only character given on which these subgenera are based, the writer feels that this division is unwarranted.

The genus *Benedenia* contains the following species: *Benedenia adenea* Meserve, 1938 (syn. *B. anadenea* Meserve, 1938), from *Mycteroperca* sp.; *B. convoluta* (Yamaguti, 1937), n. comb., from *Epinephelus akaara; B. derzhavini* (Layman, 1930), from *Sebastodes schlegelii; B. epinepheli* (Yamaguti, 1937), from *Epinephelus akaara; B. hendorffii* (Linstow, 1889), from *Coryphaena hippurus; B. ishikawae* (Goto, 1894), from *Lethrinus* sp.; B. *isabellae* Meserve, 1938, from "grouper-like fish"; *B. macrocolpa* (Lühe, 1906), from *Rhinoptera javanica; B. madai* (Ishii and Sawada, 1938), n. comb., from *Pagrosomus major; B. melleni* (MacCallum, 1927), from *Spheroides annulatus*, etc.; *B. muelleri* (Meserve, 1938), n. comb., from *Cratinus agassizii; B. monticellii* (Parona and Perugia, 1895),[2] from *Mugil auratus; B. ovata* (Goto, 1894), from *Anthias schlegelii; B. pacifica* (Guberlet, 1936), n. comb., from *Aetobatus californicus; B. pagrosomi* (Ishii and Sawada, 1938), n. comb., from *Pagrosomus major; B. sciaenae* (Beneden, 1856), from *Sciaena aquilla; B. sebastodis* (Yamaguti, 1934), from *Sebastodes inermis; B. seriolae* (Yamaguti, 1934), from *Sebastodes aureovittata;* and *B. sekii* (Yamaguti, 1937), from *Pagrosomus unicolor*. Of these species, only *B. adenea*, *B. hendorffii*, *B. isabellae*, *B. melleni*, and *B. pacifica* are known from North America.

Benedenia adenea Meserve, 1938

Synonym.—*Benedenia anadenea* Meserve, 1938.

This species was described by Meserve (1938) from specimens collected

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[2] *Benedenia monticellii*, as described by Parona and Perugia (1895), is unrecognizable; the description is little more than generic and the measurements, especially those of the organs and hooks, obviously erroneous. These authors stated that only two pairs of haptoral hooks were present, but if this be true, it is very exceptional as all other species of this group have three pairs of hooks. The size of the large hooks was given as 0.016 mm and of the smaller hooks as 0.011 mm; these probably should have been 0.16 and 0.11 mm, respectively.

by H. W. Manter from the gills of *Mycteroperca* sp. taken at Socorro Island, Mexico. The description and figures are adequate and a redescription will not be given here. A figure of the haptoral hooks (Fig. 10) is given for comparison with others of this genus from North America. Meserve has also described as a distinct species, *B. anadenea*, a form from the same host and locality as *B. adenea*. The principal difference given for the separation of the two species was the absence of the "glands of Goto" in the former. A study of the type specimen of *B. anadenea* (U. S. N. M. No. 9179) and of three paratypes kindly loaned by Dr. Manter has shown that these glands are present in both species. *B. anadenea* is, therefore, dropped as a synonym of *B. adenea*.

Benedenia isabellae Meserve, 1938

This species was described by Meserve (1938) from specimens collected from the gills of an unidentified "spotted, grouper-like fish" taken by H. W. Manter at Isabel Island, Mexico. The description is very complete and little can be added beyond the fact that marginal haptoral hooklets (larval hooks) are present; they are 14 in number and distributed as in other members of the family Capsalidae. A figure of the haptoral hooks (Fig. 11) is included, however, since it is on the basis of the hooks that this form can best be distinguished from closely related species.

Benedenia pacifica (Guberlet, 1936), n. comb.

Synonym.—Epibdella pacifica Guberlet, 1936.

This species was adequately described and figured by Guberlet (1936). However, this author failed to locate the smaller pair of haptoral hooks and their apparent absence was used as one of the differential characters. A study of the type specimens, kindly loaned by Prof. Guberlet, revealed the presence of the small hooks as well as the marginal hooklets which were not mentioned in the original description. This study also revealed that the species had been misallocated and must on the basis of the anterior haptors be assigned to the genus *Benedenia* instead of *Epibdella* (=*Entobdella*).

B. pacifica is quite distinct from all other members of the genus in that the hooks of the first pair (Fig. 12) are extremely small as compared with those of related species. The hooks of the second pair have blunt tips instead of the usual pointed recurved tips. The hooks of the third pair are smaller than in most species, being only 37μ long; they are situated near the margin of the haptor and removed a considerable distance from the tips of the second pair, the usual location. This species also appears to be unique in being devoid of eyes.

Benedenia melleni (MacCallum, 1927) Johnston, 1929

Benedenia melleni has been so adequately described by MacCallum (1927) and by Jahn and Kuhn (1932) that a redescription need not be given here. However, a figure of the haptoral hooks (Fig. 13) is included for comparison with those of related species.

B. melleni differs from most species of the genus in lacking a vagina. There are, however, three other species, *B. adenea* Meserve, *B. isabellae* Meserve and *B. muelleri* (Meserve)[3] that also appear to lack vaginae. In addition to the absence of vaginae, the haptoral hooks of these four species are so similar that these two characters taken together may ultimately be found adequate for the erection of a separate genus to contain them.

B. melleni is the least host specific of any monogenetic trematode so far described, at least 57 species of fishes representing 17 families being reported as hosts. As a rule monogenetic flukes show a high degree of host specificity, usually only one or at least only a few closely related species being susceptible to infestation. In view of the observations at the New York aquarium of Jahn and Kuhn, as well as those of Nigrelli and Breder (1934) specificity in this species is either lacking to a large extent or more apparent than real. The large variety of susceptible fish hosts suggests that infestation is perhaps a matter of opportunity, the type of circulation in the tanks where the observations were made being such as to afford a greater chance for infestation than would be possible under natural conditions.

Benedenia hendorffii (Linstow, 1889) Stiles and Hassall, 1908

Benedenia hendorffii was originally described by Linstow (1889) from specimens collected from the skin of *Coryphaena hippurus* taken at "Caleta buena, Chile." Recently the writer (Price, 1938) redescribed and reillustrated what is regarded as this species from a specimen collected by E. E. Wehr from an undetermined species of fish at Spokane, Washington. The haptoral hooks (Fig. 15) are quite different from those of other species of *Benedenia*, and these alone are sufficient to permit an identification of the species.

Genus PSEUDOBENEDENIA Johnston, 1931

Diagnosis.—Anterior haptors consisting of a pair of suckers in addition to well defined anterior glandular areas. Vagina extremely short. Other characters as in *Entobdella* and *Benedenia.*

Type species.—*Pseudobenedenia nototheniae* Johnston, 1931.

The type and only species was described by Johnston (1931), the specimens being collected from the skin of *Notothenia macrocephala* from New Zealand.

Genus ENTOBDELLA Blainville in Lamarck, 1818

Synonyms.—*Epibdella* Blainville, 1828; *Ertopdella* Rathke, 1843; *Phylline* Oken, 1815, not Abildgaard, 1790; *Phyllonella* Beneden and Hesse, 1863.

Diagnosis.—Anterior haptors in form of elongate, slightly depressed, glandular areas at anterior margin of cephalic lobe; posterior haptor sucker-

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[3] *Benedenia muelleri* was described by Meserve (1938) as *Entobdella muelleri*, the species being based on a single specimen from the gills of *Cratinus agassizii* collected at Tagus Cove, Albemarle Island, Galapagos Islands. An examination of the type specimen shows that the anterior haptors are of the *Benedenia* type rather than of the *Eutobdella* type, and the species is, therefore, transferred to *Benedenia. B. muelleri* appears on the basis of the haptoral hooks (Fig. 14), to be quite distinct from all others of the genus.

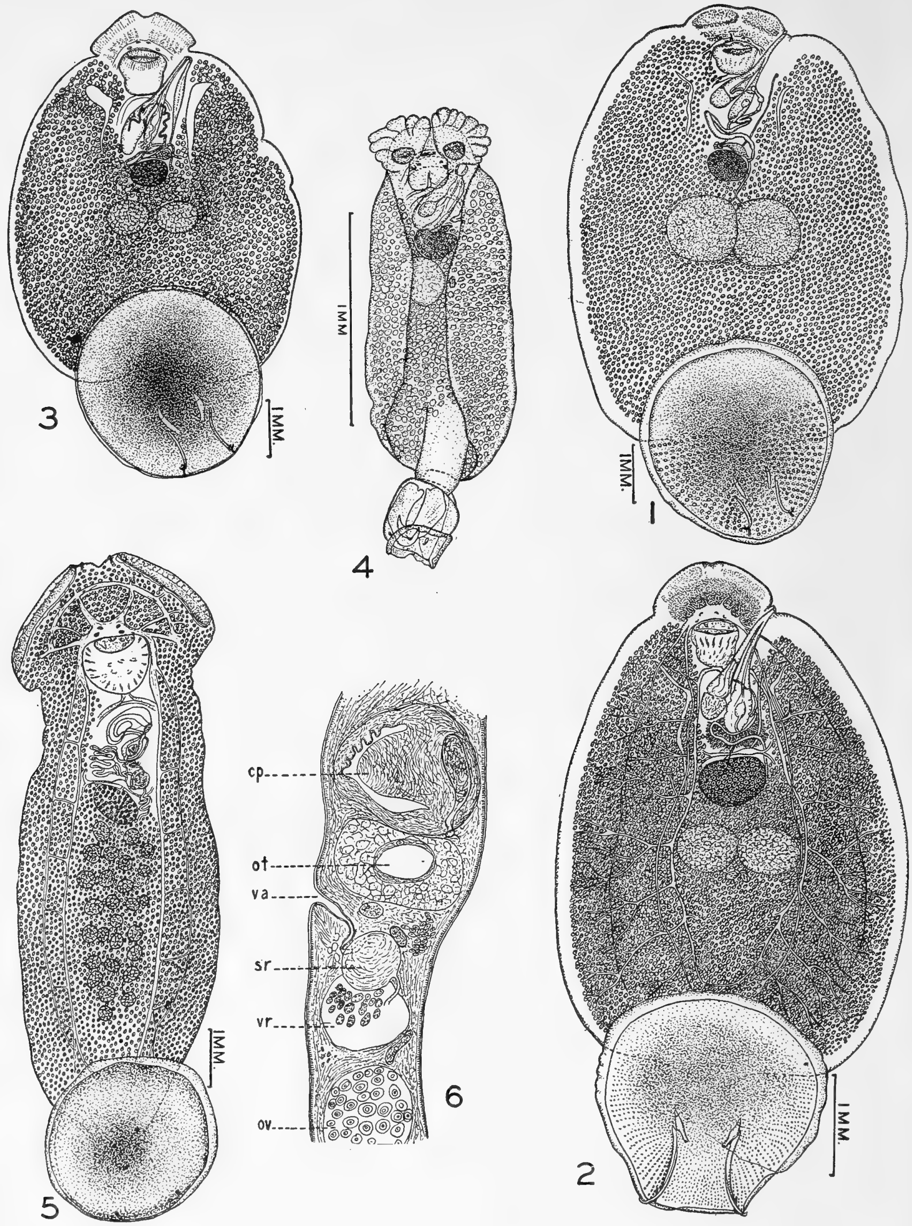


Fig. 1.—*Entobdella hippoglossi*, ventral view; Fig. 2.—*E. squamula*, ventral view; Fig. 3.—*E. bumpusii*, ventral view; Fig. 4.—*Encotyllabe lintonii*, ventral view; Figs. 5–6.—*Nitzschia superba*, 5, complete worm, ventral view; 6, section through region of genitalia (cp. cirrus pouch; ot. ootype; ov. ovary; sr. seminal receptacle; va. vaginal aperture; vr. vitelline reservoir).

like, armed with hooks as in *Benedenia.* Ovary usually separated from testes by a relatively wide band of vitelline follicles. Vas deferens forming a preovarial loop. Other characters as in *Benedenia.*

Type species.—Entobdella hippoglossi (O. F. Müller, 1776) Johnston, 1856.

This genus is better known in the literature as *Epibdella,* but Johnston (1929) has shown that this name is antedated by *Entobdella* Blainville, in Lamarck, 1818. *Entobdella* Blainville on the other hand is antedated by *Phylline* Oken, 1815, but as the latter name had been previously used by Abildgaard (1790) for a tapeworm, *Entobdella* is the oldest available name for the genus. As Johnston has pointed out, the correct date for *Entobdella* has been difficult to establish, and the following quotation from Lamarck's (1818) discussion of "PHYLLINÉ (Phylline)" is given, since it is on the basis of this statement that *Entobdella* is regarded as the correct name of the genus: "Ce genre est établi par M. Ochen, sous le nom que nous lui conservons; et néanmoins M. de Blainville, que l'avait déjà reconnu, lui assigna celui de *Entobdella,* dans ses manuscrits."

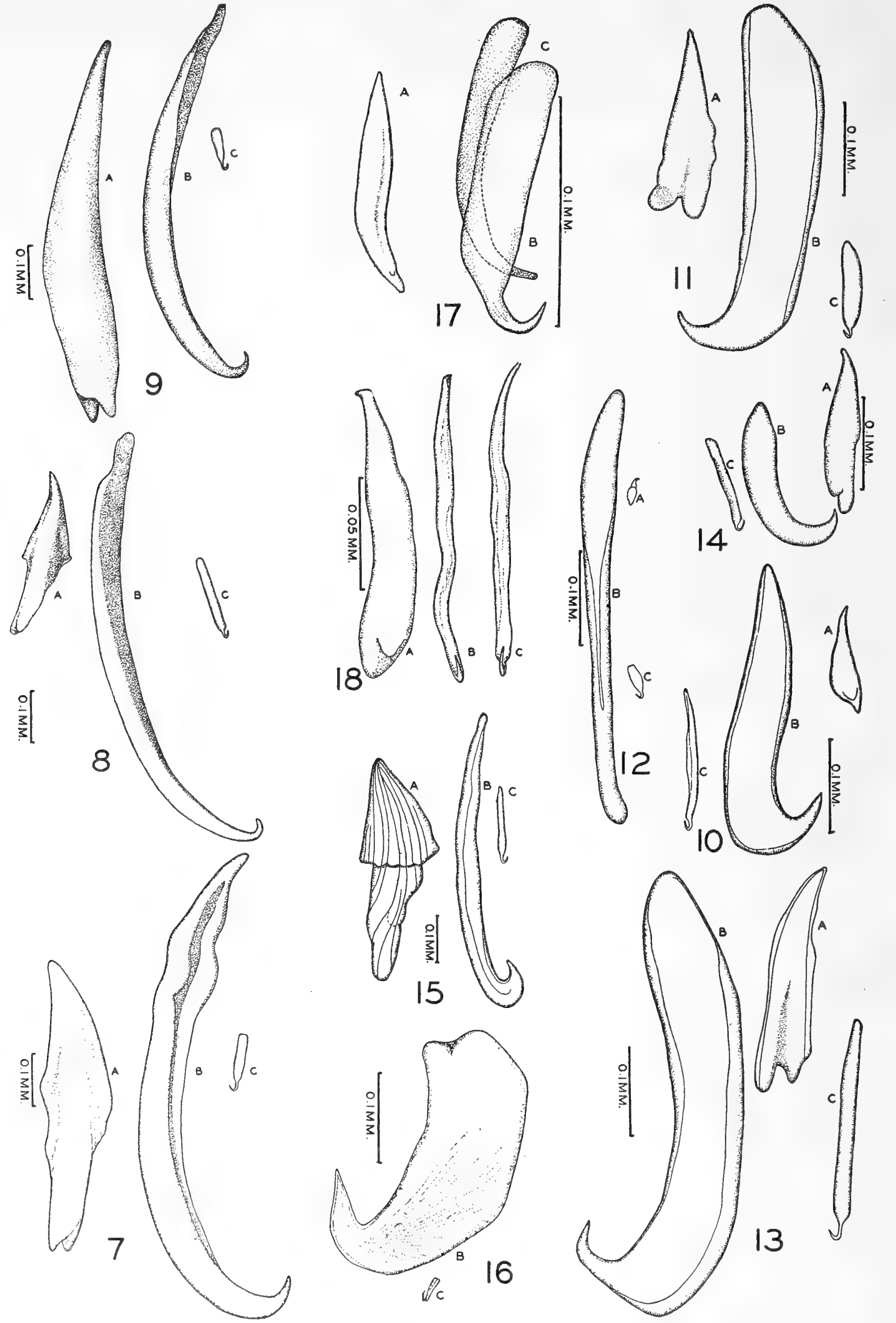
Johnston (1929) has proposed a division of the genus into 2 sub-genera, *Entobdella* and *Parepibdella.* Aside from the fact that the genus is so small that a subdivision seems unnecessary, the proposed subdivision is illogical since the species *E. diadema* and *E. bumpusii,* which bear such a close resemblance to each other that they require extremely careful study in order to find characters upon which to separate them, are placed in different subgenera.

The genus *Entobdella* contains the following species: *Entobdella bumpusii* (Linton, 1900), from *Pastinachus centrourus; E. diadema* (Monticelli, 1902), frour *Trygon violacea; E. hippoglossi* (O. F. Müller, 1776), from *Hippoglossus hippoglossus; E. soleae* (Beneden and Hesse, 1863), syn. *E. producta* (Linstow, 1903), from *Solea vulgaris; E. squamula* (Heath, 1902), from *Paralichthys californicus;* and *E. steingröveri* (Cohn, 1916), from an undetermined fish. Three of these species, *E. bumpusii, E. hippoglossi* and *E. squamula,* occur on North American hosts.

Entobdella hippoglossi (O. F. Müller, 1776) Johnston, 1856 Figs. 1, 7

Synonyms.—Hirudo hippoglossi O. F. Müller, 1776; *Phylline hippoglossi* (O. F. Müller, 1776) Oken, 1815; *Epibdella hippoglossi* (O. F. Müller, 1776) Blainville, 1828; *Tristoma hamatum* Rathke, 1843; *Nitzschia hippoglossi* (O. F. Müller, 1776) Taschenberg, 1878; *Phyllonella hippoglossi* (O. F. Müller, 1776) Goto, 1899; *Epibdella bumpusii* of Canavan, 1934.

Description.—Body elliptical, 13 to 18 mm long by 3.6 to 4.8 mm wide (up to 24 mm long and up to 11 mm wide, according to various authors); cephalic lobe set off from rest of body by slight marginal constrictions. Anterior haptors in form of 2 elongate, slightly depressed, glandular areas, 1 on each side of median line near anterior margin of cephalic lobe. Posterior haptor sucker-like, 3.6 to 4.8 mm in diameter, surrounded by marginal membrane about 170μ wide; ventral surface concave, the posterior half covered with radiating rows of more or less prominent papillae, and armed with 3



Figs. 7–18.—Haptoral hooks of: 7, *Entobdella hippoglossi;* 8, *E. squamula;* 9, *E. bumpusii;* 10, *Benedenia adenea;* 11, *B. isabellae;* 12, *B. pacifica;* 13, *B. melleni;* 14, *B. muelleri;* 15, *B. hendorffii;* 16, *Encotyllabe lintonii;* 17, *Nitzschia superba;* 18, *Megalocotyle marginata.* (A—hook of first pair; B—hook of second pair; C—hook of third pair.)

pairs of large hooks and 14 marginal hooklets. Hooks of first pair spearhead-shaped, median margin slightly curved, 510 to 640μ long; hooks of second pair slender, 815 to 935μ long, tips recurved; hooks of third pair 95 to 122μ long, tips slender and recurved; marginal hooklets about 20μ long. Oral aperture ventral, at level of lateral constrictions of body. Pharynx 680 to 850μ long by 850μ to 1.1 mm wide. Intestine as in species of *Benedenia.* Common genital aperture at left marginal constriction. Cirrus pouch club-shaped, its base to right of median line and about midway between base of pharynx and anterior margin of ovary. Testes globular, 1.7 to 2 mm in diameter, equatorial. Ovary transversely oval, 595 to 695μ long by 850μ to 1 mm wide, pretesticular, separated from anterior margins of testes by wide band of vitelline follicles. Vitelline follicles occupying almost entire body from level of oral aperture to posterior end of body proper. Vagina slender, opening postero-median of common genital aperture. Ootype oval, lying in median line posterior to cirrus pouch; metraterm slender. Egg tetrahedral, about 228μ wide, with long, slender filament.

Host.—Hippoglossus hippoglossus (Linn.).

Location.—Skin.

Distribution.—United States (Woods Hole, Mass., Swans Island, Me.), Alaska, Canada (Nova Scotia) and Greenland.

Specimens.—U. S. N. M. Helm. Coll. Nos. 6883, 6884, 6974, 7151, 7177, 7181, 7188, 7627, and 25051.

The specimens available to the writer correspond in all essentials with those described by earlier writers. It is the best known and most widely distributed of all species of the genus, and further comment appears unnecessary.

Canavan (1934) reported *Epibdella bumpusii* (Linton) from a member of the family Gadidae. However, an examination of the specimen by the writer showed it to be *E. hippoglossii* and not *E. bumpusi.*

Entobdella squamula (Heath, 1902) Johnston, 1929 Figs. 2, 8

Synonyms.—Epidella squamula Heath 1902; *Phylline squamula* (Heath, 1902) Linstow, 1903; *Epibdella* (*Phylline*) *squamula* (Heath, 1902) Monticelli, 1905; *Entobdella* (*Entobdella*) *squamula* (Heath, 1902) Johnston, 1929.

Description.—Body more or less elliptical, 5 to 12 mm long by 3 to 6 mm wide (3.6 to 18 mm long by 1.5 to 10 mm wide, according to Heath (1902)). Anterior haptors in form of 2 elliptical, slightly depressed, glandular areas near anterior margin of cephalic lobe. Posterior haptor sucker-like, 1.5 to 2.9 mm long by 1.4 to 2.9 mm wide, surrounded by delicate marginal membrane 170 to 240μ wide; posterior two-thirds of ventral surface covered with radiating rows of small papillae similar to those in *E. hippoglossi* and *E. steingröveri,* and armed with 3 pairs of large hooks and 14 marginal hooklets. Hooks of first pair spearhead-shaped, 197 to 274μ long; hooks of second pair slender, 595 to 986μ long, tips recurved; hooks of third pair 121 to 163μ long, tips slender and recurved; marginal hooklets about 15μ long. Oral aperture median, slightly posterior to marginal constrictions of body. Pharynx with slight constriction, 304 to 756μ long by 342 to 850μ wide; esophagus absent; intestinal limbs slender, uniting posteriorly, each limb with about 9 lateral and fewer median diverticula. Common genital aperture at left lateral constriction; cirrus pouch club-shaped, its base to right of median line about midway between base of pharynx and anterior margin of ovary. Testes usually spherical, 510μ to 1.1 mm in diameter, equatorial. Ovary ovoid, 230 to 800μ long by 510μ to 1 mm wide, pretesticular and separated from testes by wide band of vitelline follicles. Vitelline follicles occupying greater part of body from level of oral aperture to posterior end of body proper. Vagina long and slender, opening at level of base of pharynx about midway between median line and left margin of body. Ootype relatively large, its base median and immediately posterior to cirrus pouch; metraterm relatively long. Egg triangular, about 150μ wide, with long, slender apical filament.

Host.—*Paralichthys californicus* (Ayres).

Location.—Under surface of body, rarely gill chambers.

Distribution.—United States (Monterey Bay, Calif., and Gulf of Mexico).

Specimens.—U. S. N. M. Helm. Coll. Nos. 6973 (paratypes), 39579 and 39581.

This description is based on specimens collected by Prof. Harold Heath and donated to the U. S. National Museum, as well as on specimens donated to the writer by E. E. Wehr, which had been collected by Ralph A. Coombs from an undetermined fish presumably from the Gulf of Mexico.

Entobdella squamula resembles *E. hippoglossi* and *E. steingröveri* more closely than any of the other species of the genus. These species show radiating rows of papillae on the posterior haptor and, except for size, agree closely in other respects. *E. squamula* may be distinguished from both *E. hippoglossi* and *E. steingröveri* by the haptoral hooks, those of the first pair of *E. squamula* being much shorter as compared with those of the second pair than in the other two species.

Entobdella bumpusii (Linton, 1900) Johnston, 1929 Figs. 3, 9

Synonyms.—*Epibdella bumpusii* Linton, 1900; *Phylline bumpusii* (Linton, 1900) Linstow, 1903; *Entobdella* (*Parepibdella*) *bumpusii* (Linton, 1900) Johnston, 1929.

Description.—Body ovoid, 8.5 to 9 mm long by 5 to 5.5 mm wide (living specimen 12.5 mm long by 8.35 mm wide, according to Linton (1900)). Anterior haptors in form of 2 glandular areas at anterior end of cephalic lobe, each haptor crossed antero-posteriorly by about 20 relatively deep grooves. Posterior haptor sucker-like, 2.4 to 3 mm in diameter, surrounded by a delicate marginal membrane; ventral surface without papillae, armed with 3 pairs of large hooks and 14 marginal hooklets. Hooks of first pair robust, 646 to 795μ long, slightly curved, gradually attenuated anteriorly; hooks of second pair slender, 731 to 765μ long, tips recurved; hooks of third pair about 76μ long, tips slender and recurved; marginal hooklets 15μ long. Oral aperture median, at level of lateral constrictions of body. Pharynx somewhat beaker-shaped, 680μ long by 850μ wide; intestinal tract as in *E. squamula*. Common genital aperture sinistral, at level of oral aperture. Cirrus pouch club-shaped, its base to right of median line and separated from ovary by a loop of the vas deferens. Testes globular or transversely oval, 595 to 765μ long by 765 to 850μ wide. Ovary median, 595μ long by 680μ wide, pretesticular and separated from testes by wide band of vitelline follicles. Vitelline follicles occupying almost entire body width from level of oral aperture to posterior end of body proper. Vagina long, muscular, opening at side of common genital aperture. Ootype elliptical, median; metraterm slender, opening into genital atrium near common genital aperture. Eggs not observed; tetrahedral, with long, slender filament, according to Linton.

Host.—*Pastinachus centrourus* (Mitchill).

Location.—Skin and gills.

Distribution.—United States (Woods Hole, Mass.) and Canada (Labrador).

Specimen.—U. S. N. M. Helm. Coll. No. 6509.

This species is closely related to *Entobdella diadema* (Monticelli) but is easily separated from that species by the relation of the ovary to the testes; in *E. bumpusii* the ovary is separated from the testes by a wide band of vitelline follicles, while in *E. diadema* the ovary is situated immediately in front of, and in contact with, the testes. Both species resemble each other in having the anterior haptors crossed antero-posteriorly by about 20 grooves, a condition not known to occur in any of the other species.

Genus ENCOTYLLABE Diesing, 1850

Synonym.—*Cheloniella* Beneden and Hesse, 1863.

Diagnosis.—Body with lateral margins turned ventrally. Anterior haptors muscular, sucker-like, elliptical, surrounded by a wide, more or less pleated membrane. Posterior haptor campanulate, without radial septa, armed with 2 pairs of large hooks (1 pair massive) and a number (?14) of marginal hooklets, situated on a relatively long pedicel attached to the ventral surface of body. Genital aperture submedian to lateral; genital organs arranged as in *Trochopus.*

Type species.—*Encotyllabe nordmanni* Diesing, 1850.

The genus *Encotyllabe* contains seven species as follows:[4] *Encotyllabe lintonii* Monticelli, 1909, from *Calamus calamus; E. masu* Ishii and Sawada, 1938, from *Oncorhynchus masou; E. nordmanni* Diesing, 1850, from *Brama mediterranea, B. raii,* and *Heliastes chromis; E. pagelli* Beneden and Hesse, 1863, from *Pagellus centrodontus; E. pagrosomi* MacCallum, 1917, from *Pagrosomus auratus; E. paronae* Monticelli, 1907, from *Crenilabrus pavo; E. spari* Yamaguti, 1934, from *Sparus macrocephalus, Plectorhynchus pictus,* and *Epinephelus akaara;* and *E. vallei* Monticelli, 1907, from *Chrysophrys aurata.* Only one of these species, *E. lintonii,* is known from a North American host.

Encotyllabe lintonii Monticelli, 1909 Figs. 4, 16

Synonym.—*Encotyllabe* sp. Linton, 1907.

Description.—Body ellipsoidal, 2 mm long by 765μ wide disregarding infolded margins, or about 1.2 mm wide if spread out. Margins of body infolded ventrally forming a spacious groove. Anterior haptors sucker-like, 76μ long by 84μ wide, incompletely surrounded by a pleated membrane about 306μ across. Posterior haptor pedunculated, bell-shaped, about 340μ long, and surrounded by a delicate marginal membrane; large hooks robust, 274μ long, small hooks 30μ long; marginal hooklets 10μ long, number not ascer-

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[4] Perrier (1897) in a discussion of the shape of eggs of tristomes mentioned the name *Encotyllabe fragile,* but so far as the writer has been able to ascertain no such species has ever been described. *E. fragile,* therefore, must be regarded as a *nomen nudum* and without nomenclatural status.

tainable; pedicel 380μ long by 237μ wide. Pharynx almost rectangular, 152μ long by 190μ wide. Genital aperture at side of pharynx, a short distance posterior to left anterior haptor. Cirrus pouch robust, its base lying posterior to pharynx and to right of median line. Right testis oval, 228μ long by 190μ wide; left testis missing, its location marked by a small scar-like mass of tissue. Ovary 114μ long by 190μ wide, median, pretesticular. Vitelline follicles occupying almost entire body width from level of pharynx to posterior end of body proper. Vaginal aperture preovarial and slightly sinistral. Ootype indistinct, immediately posterior to, and partly overlying, cirrus pouch. No eggs present.

Host.—*Calamus calamus* (Cuvier and Valenciennes).

Location.—Gills.

Distribution.—Bermuda.

Specimen.—Collection of Prof. Edwin Linton, University of Pennsylvania, Philadelphia, Pa. (type).

This species is represented by a single, somewhat immature specimen collected by Prof. Edwin Linton, July 16, 1903, at the Bermuda Biological Station for Research, Flatts, Bermuda. As Linton's description of this form was incomplete in certain details, Monticelli (1908) secured the specimen and redescribed it, naming the species for the collector. Monticelli's description was brief and inaccurate as the writer has found on studying the specimen kindly loaned him by Prof. Linton; the inaccuracies are as follows: The figure given by Monticelli, labelled ventral view, is actually a dorsal view and shows 2 testes situated side by side, while the specimen, being anomalous, has only 1 testis, a small scar-like mass representing the other testis; the ovary is much larger than Monticelli's description would indicate; the genital aperture is at the left side of the pharynx and not posterior to it as Monticelli stated; and the ratio of the hook lengths is 1:9 instead of 1:8.

Both Monticelli and Linton overlooked the small marginal haptoral hooklets. These hooklets have previously been reported as present on only one species of the genus, *E. pagrosomi* MacCallum (Price, 1937), but in view of the fact that they are now known to occur on two of the seven species it may be assumed that they are present on all.

Yamaguti (1934) has described a species, *Encotyllabe spari*, from Japanese fishes, which appears to be very close to, if not actually the same as, *E. lintonii*. The measurements given for *E. spari* are slightly in excess of those of *E. lintonii* but these slight differences may not be significant, especially since the latter species is known from only a single anomalous specimen. However, since our knowledge of *E. lintonii* is inadequate, the writer prefers to retain Yamaguti's species until more specimens of *E. lintonii* are available, or until a more adequate description based on new material has been given.

Genus ANCYROCOTYLE Parona and Monticelli, 1903

Diagnosis.—Anterior haptors in form of 2 muscular suckers, each situated on a fleshy pad. Posterior haptor sucker-like, with marginal membrane, bearing 3 pairs of large hooks and 14 marginal hooklets; hooks of third pair lateral to those of second pair. Intestinal tract consisting of 2 ceca, without lateral or median branches and not united posteriorly. Testes 2, postovarial, or (?) 1, preovarial. Vagina present.

Type species.—Ancyrocotyle vallei (Parona and Perugia, 1895) Parona and Monticelli, 1903.

Only one species. *Ancyrocotyle bartschi*, in addition to the genotype, has been allocated to this genus. This species was described by the writer (Price, 1934) from two immature specimens collected from the gills of *Naucrates ductor* taken in West Indian Waters. The original description is regarded as adequate for the purpose of identification and further consideration of *A. bartschi* will not be given in this paper.

Subfamily NITZSCHIINAE Johnston, 1931

Diagnosis.—Anterior haptors in form of 2 sucker-like grooves, 1 on each side of median line of cephalic lobe. Posterior haptor sucker-like, surrounded by well developed marginal membrane; ventral surface strongly concave, without papillae or septa, and armed with 3 pairs of hooks and 14 marginal hooklets. Genital aperture postpharyngeal, median or sinistral. Testes numerous (up to 27 or more), in interintestinal field. Ovary entire. Vagina present.

Type genus.—Nitzschia Baer, 1826.

Genus NITZSCHIA Baer, 1826

Diagnosis.—Characters of subfamily.

Type species.—Nitzschia elegans Baer, 1826 (=*N. sturionis* (Abildgaard, 1794).

Up to the present time only two species have been included in the genus *Nitzschia*, namely, *Nitzschia sturionis* (Abildgaard, 1794), from *Acipenser sturio*, and *N. superba* MacCallum, 1921, from *A. brevirostris*. In addition to these two species, a third, *N. monticellii*, n. sp.,[5] is here proposed for the "forma giovane" of *N. elongata* (Nitzsch) (=*N. sturionis* described from Europe by Monticelli (1909)).

Nitzschia superba MacCallum, 1921 Figs. 5–6, 17

Description.—Body elongated, 8 to 15 mm long by 2.1 to 3.5 mm wide, somewhat constricted in region of pharynx. Anterior haptors in form of elongated grooves, 1.6 to 1.8 mm long, 1 on each side of median line and lying along margins of cephalic lobe. Posterior haptor sucker-like, surrounded by well developed marginal membrane 170μ wide; ventral surface strongly concave, without radial septa or papillae, armed with 3 pairs of hooks and 14 marginal hooklets. Hooks of first pair straight, somewhat fusiform, 85 to 120μ long; hooks of second and third pairs equal, 106 to 167μ long, those of second pair with slender recurved tips and those of third pair with relatively thick, blunt tips, not recurved; marginal hooklets 20μ long. Oral aperture median, at level of posterior ends of anterior haptors. Pharynx subglobular, 765μ to 1 mm long by 765μ to 1.2 mm wide. Genital

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[5] *N. monticelli* is regarded as new on the basis of inequality of the lengths of the haptoral hooks on Monticelli's "forma giovane" of *N. elongata* (=*N. sturionis*). The haptoral hooks of *N. sturionis* are equal in length, or nearly so, and as it has been the writer's experience that the hooks of monogenetic trematodes do not exhibit material variation due to age, it seems reasonably certain that two species were represented in Monticelli's material.

aperture sinistral, 340 to 510μ posterior to base of pharynx. Cirrus pouch short and thick, directed transversely; testes 26 to 27 in number, in median field, postovarial. Ovary oval to somewhat reniform, 346 to 595μ long by 680 to 800μ wide, median, preequatorial. Vitelline follicles very numerous, occupying entire body width from anterior end of cephalic lobe to posterior end of body proper. Vaginal aperture median, near base of ootype; vagina short and relatively wide, connected with a large, globular seminal receptacle lying antero-lateral of vitelline reservoir. Ootype piriform, its base lying in median line posterior to cirrus pouch; metraterm very short. Egg triangular in outline, 171μ wide, with moderately long, slender filament.

Hosts.—Acipenser brevirostris Le Sueur, *A. sturio* Linnaeus, and *A. oxyrhynchus* Mitchill.

Location.—Gills.

Localities.—United States (New York Aquarium, Woods Hole, Mass., and Block Island) and Canada (Gulf of St. Lawrence).

Specimens.—U. S. N. M. Helm. Coll. Nos. 4873, 7153, 7742, 35639, 35640 (cotypes) and 35641.

Nitzschia superba was described by MacCallum (1921) from specimens collected at the New York Aquarium from a short-nosed sturgeon taken along the Atlantic Coast. MacCallum did not give any very clear differences between this species and the other species of the genus except for the character of the vitellaria which he stated "was very different from that of other members of the genus, inasmuch as instead of being a mass of more or less circular glands, they are here in the form of tubes with only at short distances a circular gland here and there." A study of the specimens on which MacCallum's description of *N. superba* was based shows that the character of the vitellaria is not different from that of other species, since the tubes he mentioned were the small collecting ducts and not the vitelline follicles. The principal difference between *N. superba* and the European species lies in the morphology of the hooks of the posterior haptor.

So far as the writer has been able to ascertain *N. superba* is the only species known from American hosts. Specimens (U. S. N. M. No. 4873) collected by Linton, as well as specimens collected by MacCallum, and labelled *N. elegans* were found on examination to be *N. superba*. One additional specimen (U. S. N. M. No. 7153), the host of which was not given, proved to be also *N. superba*. In view of the fact that all of the specimens so far examined have proved to be *N. superba*, it seems reasonable to assume that the records of *N. elegans* by Verrill (1875) from *Acipenser oxyrhynchus*, by Linton (1898 and 1901) and by Stafford (1904) from *A. sturio* are probably those of *N. superba* also.

Subfamily TROCHOPINAE Price, 1936

Diagnosis.—Anterior haptors in form of suckers or glandular areas; posterior haptor sucker-like, subsessile, its ventral surface divided into central and marginal areas by ridges or septa. Other characters as in Benedeniinae.

Type genus.—Trochopus Diesing, 1850.

KEY TO GENERA OF TROCHOPINAE

1. Anterior haptors in form of glandular areas.....*Macrophyllida* Johnston
   Anterior haptors in the form of suckers..........................2
2. Posterior haptor with 10 rays......................*Trochopus* Diesing
   Posterior haptor with 6 to 7 rays ....*Megalocotyle* Folda

Genus TROCHOPUS Diesing, 1850

Diagnosis.—Anterior haptors disc-like, medium-sized, subsessile, varying in form and appearance. Posterior haptor disc-like, subsessile, with marginal membrane; ventral surface divided into cavities by 10 ridges or septa, armed with 2 to 3 pairs of large hooks and 14 marginal hooklets. Genital aperture at level of posterior margin of left anterior haptor; genital atrium long; cirrus pouch curved, its base usually to right of median line; testes 2, oval, with zones coinciding and with fields abutting or separate, usually equatorial or preequatorial. Ovary globular, pretesticular. Vagina slender, opening immediately posterior to common genital aperture.

Type species.—*Trochopus longipes* Diesing, 1850 (=*Tristoma tubiporum* Diesing, 1836, renamed).

There are at present 10 species in the genus *Trochopus* as follows: *Trochopus brauni* Mola, 1912, from *Cottus gobio; T. differens* Sonsino, 1891, from *Cantharus lineatus; T. diplacanthus* Massa, 1903, from *Trigla hirundo; T. gaillimhe* Little, 1929, from *Trigla hirundo* or *T. lucerna; T. heterachanthus* Massa, 1903, from *Trigla corax; T. lineatus* Scott, 1901, from *Trigla lineata; T. micrachanthus* Massa, 1903, from *Trigla hirundo; T. onchacanthus* Massa, 1906, from undetermined fish host; *T. pini* (Beneden and Hesse, 1863), from *Trigla pini, T. hirundo* and *T. corax;* and *T. tubiporus* (Diesing, 1835), from *Trigla hirundo.* No member of this genus has been reported from North America.

Genus MEGALOCOTYLE Folda, 1928

Diagnosis.—Posterior haptor with (?) 6 to 7 septa. Other characters as in *Trochopus.*

Type species.—*Megalocotyle marginata* Folda, 1928.

The present writer (Price, 1936) has previously stated that *Megalocotyle* Folda was a synonym of *Trochopus* Diesing. This position would not be difficult to maintain, but since *Trochopus* (*sensu lato*) can be separated on the basis of the haptoral rays into two distinct groups of species it now seems desirable, at least for convenience, to regard *Megalocotyle* as valid.

Five species may be included in the genus *Megalocotyle: M. hexacanthus* (Parona and Perugia, 1889), n. comb., from *Serranus gigas; M. marginata* Folda, 1928, from *Sebastodes nebulosis; M. rhombi* (Beneden and Hesse, 1863), n. comb., from *Rhombus maximus; M. squatinae* (MacCallum, 1921) n. comb., from *Squatina squatina;* and *M. zschokkei* (Mola, 1912), n. comb., from *Cottus gobio.* Of these species only *M. marginata* is known from North America.

Megalocotyle marginata Folda, 1928

This species has been adequately described by Folda (1928) and a redescription need not be given here. A study of some of the paratype specimens

(U. S. N. M. No. 39580) kindly donated by Prof. J. E. Guberlet, University of Washington, Seattle, Wash., however, shows that Folda apparently erred in describing and figuring the first pair of haptoral hooks. These were shown to have posteriorly directed projections at or near the middle of the hooks, but these projections are apparently wrinkles of the cuticula at the opening of the hook sheath and not a part of the hook proper (Fig. 18).

Genus MACROPHYLLIDA Johnston, 1929

Synonym.—*Macrophylla* Hughes, 1928, not Hope, 1837.

Diagnosis.—Anterior haptors in form of fan-like glandular areas. Posterior haptor similar to that of *Trochopus*. Testes 2, preequatorial, one slightly anterior to other.

Type species.—*Macrophyllida antarctica* (Hughes, 1928) Johnston, 1929.

The type and only species of this genus was described by Hughes (1928) from *Mustelus antarcticus* in Australia.

Subfamily CAPSALINAE Johnston, 1929

Synonyms.—*Tristominae* Braun 1893; *Tristomatinae* Gamble, 1896.

Diagnosis.—Anterior haptors sucker-like. Posterior haptor sucker-like, subsessile, its ventral surface divided by septa into a central polygonal area and 7 marginal, more or less triangular areas, usually armed with 1 pair of large spine-like hooks and 14 marginal hooklets. Testes numerous, confined to interintestinal field or extending into extraintestinal fields. Ovary lobulate.

Type genus.—*Capsala* Bosc, 1811.

KEY TO GENERA OF CAPSALINAE

1. Pharynx with constriction; testes usually, if not always, extending into extraintestinal fields . . . . *Capsala* Bosc
   Pharynx without constriction; testes confined to interintestinal field . . 2
2. Posterior rays of haptor bifid distally; haptoral hooks with claw-like tips; dorsal marginal spines crown-shaped, in single longitudinal row . . . . *Capsaloides* Price
   Posterior rays of haptor not bifid distally; haptoral hooks without claw-like tips; dorsal marginal spines, when present, not crown-like, in numerous short transverse rows . . . . *Tristoma* Cuvier

Genus CAPSALA Bosc, 1811

Synonym.—*Tristoma* Cuvier, 1817, in part.

Diagnosis.—Dorsal marginal spines present or absent. Posterior rays of haptor not bifid distally; hooks, when present, simple, without claw-like tips. Pharynx with a definite constriction at or posterior to middle. Testes numerous, usually, if not always, extending into extraintestinal fields.

Type species.—*Capsala martinieri* Bosc, 1811.

The following species may be included in the genus *Capsala; Capsala biparasitica* (Goto, 1894), from carapace of a copepod, probably *Parapetalus* sp., parasitic on the gills of *Thynnus albacora; C. foliacea* (Goto, 1894), from undetermined Japanese fish; *C. interrupta* (Monticelli, 1891), from *Thynnus brachypterus; C. katsuwona* (Ishii, 1936), from *Katsuwonus vagans; C. laevis*

(Verrill, 1875), from *Tetrapturus imperator*, *T. brevirostris* and *Coryphaena hippurus; C. lintoni*, n. sp., from *Gymnosarda pelamis; C. maccallumi*, n. sp., from *Euthynnus alletteratus; C. magrona* (Ishii, 1936),[6] from *Thynnus orientalis; C. martinieri* (Bosc, 1811), from *Mola mola; C. megacotyle* (Linstow, 1906), from *Histiophorus* sp.; *C. nozawae* (Goto, 1894), from *Thynnus sibi; C. onchidiocotyle* (Setti, 1899), from *Thynnus thynnus; C. ovale* (Goto, 1894), from *Histiophorus orientalis*, *Histiophorus* sp., and (?) *Cybium* sp.; *C. pelamydis* (Taschenberg, 1878), from *Pelamys sarda; C. poeyi* (Vigueras, 1935), from *Makaira ampla;* and possibly *C. squali* (E. Blanchard, 1847), at present unrecognizable, from *Squalus* sp.

Capsala martinieri, *C. laevis*, *C. lintoni*, *C. maccallumi* and *C. poeyi* are the North American representatives of this genus.

Capsala martinieri Bosc, 1811 Figs. 19–21

Synonyms.—*Phylline diodontis* Oken, 1815, *P. coccinea* of Schweigger, 1820; *Tristoma maculatum* Rudolphi, 1819; *T. coccineum* of Rudolphi, 1819; *T. coccineum* of Bremser, 1824; *T. coccineum* of Diesing, 1836; *T. cephala* Risso, 1826; *T. molae* E. Blanchard, 1847; *T. rudolphianum* Diesing, 1850; *Capsala maculata* (Rudolphi, 1819) Nordmann, in Lamarck, 1840; *C. rudolphiana* (Diesing, 1850) Johnston, 1865; *C. sanguinea* Diesing, 1850; *C. cephala* (Risso, 1826) Johnston, 1929; *C. molae* (E. Blanchard, 1847) Johnston, 1929.

Description.—Body cordate to almost circular, 15 to 21 mm long by 16 to 21 mm wide, posterior end deeply notched; dorsal surface convex, smooth except near margins, the margins with a relatively wide longitudinal band of irregularly placed spines, the majority of spines 4-cuspid; ventral surface concave, covered with minute papilliform projections. Anterior haptors sucker-like, circular or slightly oval, 1.4 to 1.8 mm in diameter. Posterior haptor circular, 8 to 10 mm in diameter, surrounded by pleated marginal membrane 500μ wide; ventral surface covered with minute papilliform projections; central area an irregular heptagon with 7 ridges or septa radiating from it; no hooks present; marginal hooklets present, small. Oral aperture median, at level of posterior margins of anterior haptors. Pharynx 2 to 2.1 mm long by 1 to 1.8 mm wide, with distinct constriction. Intestine as in other capsalids. Genital aperture sinistral, at level of equator of pharynx. Cirrus pouch club-shaped, its base lying in median line posterior to pharynx. Testes very numerous, occupying greater part of central area of body and extending laterally to within about 1.5 mm of body margins and anteriorly to about level of base of pharynx. Ovary lobulate, 1.5 to 2.1 mm long by 2 to 3.2 mm wide, median, about 1.5 to 2 mm posterior to base of pharynx. Vitelline follicles occupying greater part of body and extending into cephalic lobe. Vagina slender, opening 400 to 450μ posterolateral of genital aperture. Ootype oval, immediately posterior to cirrus pouch. No eggs observed.

Host.—*Mola mola* (Linnaeus).

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[6] Through the courtesy of Prof. Ishii the writer has been permitted to examine the type specimens of both *C. magrona* and *C. katsuwona*. The figures and descriptions of these forms by Ishii (1936) and the redescriptions by Ishii and Sawada (1938) are quite complete except in the case of *C. magrona*. In neither of the papers referred to is there any mention of the presence of dorsal marginal spines or of haptoral papillae in this species. These spines are small, unicuspid, and distributed in much the same manner as in *C. martinieri*. The haptoral papillae are relatively large, not numerous, and irregularly distributed in the depressions between the haptoral radii.

Location.—Skin.

Distribution.—United States (Atlantic and Pacific Coasts).

Specimens.—U. S. N. M. Helm. Coll. Nos. 3989, 4879, 7164, 7186, 7187, 7338, 7741, 35266, 35332, 35642 and 35643.

La Martinière (1787) described an ectoparasitic fluke, which he did not name, from a fish of the genus *Diodon.* The complete account of this worm is as follows:

> L'insecte suivant (*fig. 4 et 5*) a à peu près la forme d'un verre de montre qui serait échancré dans un point de sa circonférence; son corps est d'une consistance cartilagineuse, d'une couleur blanche un peu terne; sa partie supérieure (*fig. 4* [A]) est couverte par de petites taches ovales, de couleur de lie de vin. La *fig. 5* [B] le représente vu par-dessous, où l'on aperçoit trois élévations en forme de godets, deux vers la trompe de l'animal, et une troisième beaucoup plus grande, vers la partie échancrée de son corps; ce dernier est divisé par sept petites côtes blanchâtres; le centre fait un peu saille. C'est à la faveur de ces différens godets qu'il se fixe d'une manière très-forte sur le corps de différens poissons ou animaux marins; vraisemblablement c'est en faisant le vide, et non avec une humeur glutineuse et tenace qu'on pourrait lui supposer. Peut-être est-ce par cette même cause que les lépas et les moules se fixent si fortement aux rochers. Sa trompe, qui est située entre ses deux petits godets supérieurs, a son extrémité supérieure hérissée de pointes, qui doivent être autant de pouches par où cet animal suce le sang des poissons sur lesquels il est fixé. On voit, au-dessous, à travers sa substance, plusieurs circonvolutions d'intestins qui aboutissent à un petit réservoir de forme presque carrée. Quoique cet animal soit sans jambes, il jouit d'un mouvement progressif à la faveur de ses trois espèces de godets, qu'il fixe alternativement. Il peut aussi aller au fond de l'eau, quoique sa forme paraisse devoir s'y opposer; et voici de quelle manière il l'exécute: il se roule en papillote, et se maintient dans cette situation, en fixant ses deux godets supérieurs sur la partie postérieure et supérieure de son corps; alors, présentant moins de surface, il descend au fond par son propre poids. Je l'ai trouvé fixé sur le corps d'un poisson du genre des diodons de Linné, que nous avons rencontré assez souvent depuis Nootka jusqu'à Monterey en Californie.

Bosc (1811) on the basis of La Martinière's description proposed for this species the name *Capsala martinieri.* Later Oken (1815) renamed this worm *Phylline diodontis,* and still later Rudolphi (1819) renamed it *Tristoma maculatum.* The descriptions given by Oken and by Rudolphi were taken apparently from that of La Martinière's as nothing in their descriptions indicated that they had ever seen the parasite. Bosc gave the size of the worm as 3 cm. but this measurement was evidently taken from La Martinière's illustration. Dujardin (1845) and Saint-Remy (1891) gave the size as 22.5 mm long by 18 mm wide, but just how they arrived at this is not given.

As will be noted from the original description, no details are given by which the species can be recognized. However, on the basis of circumstantial evidence the writer feels convinced that the species is identical with that commonly known as *Tristoma molae;* the evidence that led him to this conclusion is briefly this: The general body form, relative size of the haptors and body proportions are the same as those for *T. molae;* the only fish occurring in Monterey Bay and northward that would fit the diagnosis of the genus *Diodon* as given in the literature of that time, according to Dr. G. S. Myers formerly of the U. S. National Museum, would be *Diodon mola* (=*Mola mola*); the only tristome definitely known to occur on *Mola mola* is the species commonly known as *Tristoma molae;* the "spots" referred to in La Martinière's description probably were mottling commonly present in specimens and due to the contrast between the darker intestinal ramifications and the lighter body tissue; and finally, the "trompe, que est situé entre ses deux petits godets supérieurs, a son extrémité supérieure hérissé de pointes" was probably the pharynx which was protruded through the oral aperture, a condition which the writer has observed in a few specimens of *T. molae.*

The most outstanding characters which differentiate this species from others in the genus are the absence of large hooks on the posterior haptor and the arrangement of the spines occurring dorsally along the margins of the body. These spines have a haphazard arrangement and do not occur in either longitudinal or transverse rows. Parona and Perugia (1889) state that these spines occur in a regular series ("Invece questa armatura chitinosa e disposta regularmente a serie sul margini dell'animale . . . "), but the writer has not observed such an arrangement in any of the specimens available to him.

Capsala maccallumi, n. sp. Figs. 22–23

Description.—Body oblong, 2.6 mm long by 1 mm wide; dorsal and ventral surfaces smooth. Anterior haptors about 350μ in diameter. Posterior haptor about 900μ in diameter, with pleated marginal membrane about 120μ wide; ventral surface covered with prominent conical papillae; central area of haptor an irregular heptagon; hooks 95μ long, their free ends slender and hooked; marginal hooklets 14 in number, about 22μ long. Oral aperture at level of posterior margins of anterior haptors; pharynx constricted, about 300μ long by 266μ wide; intestinal tract as in other species of genus. Common genital aperture lateral; testes apparently extending beyond confines of intestinal tract; remainder of genitalia not developed sufficiently to be made out with certainty.

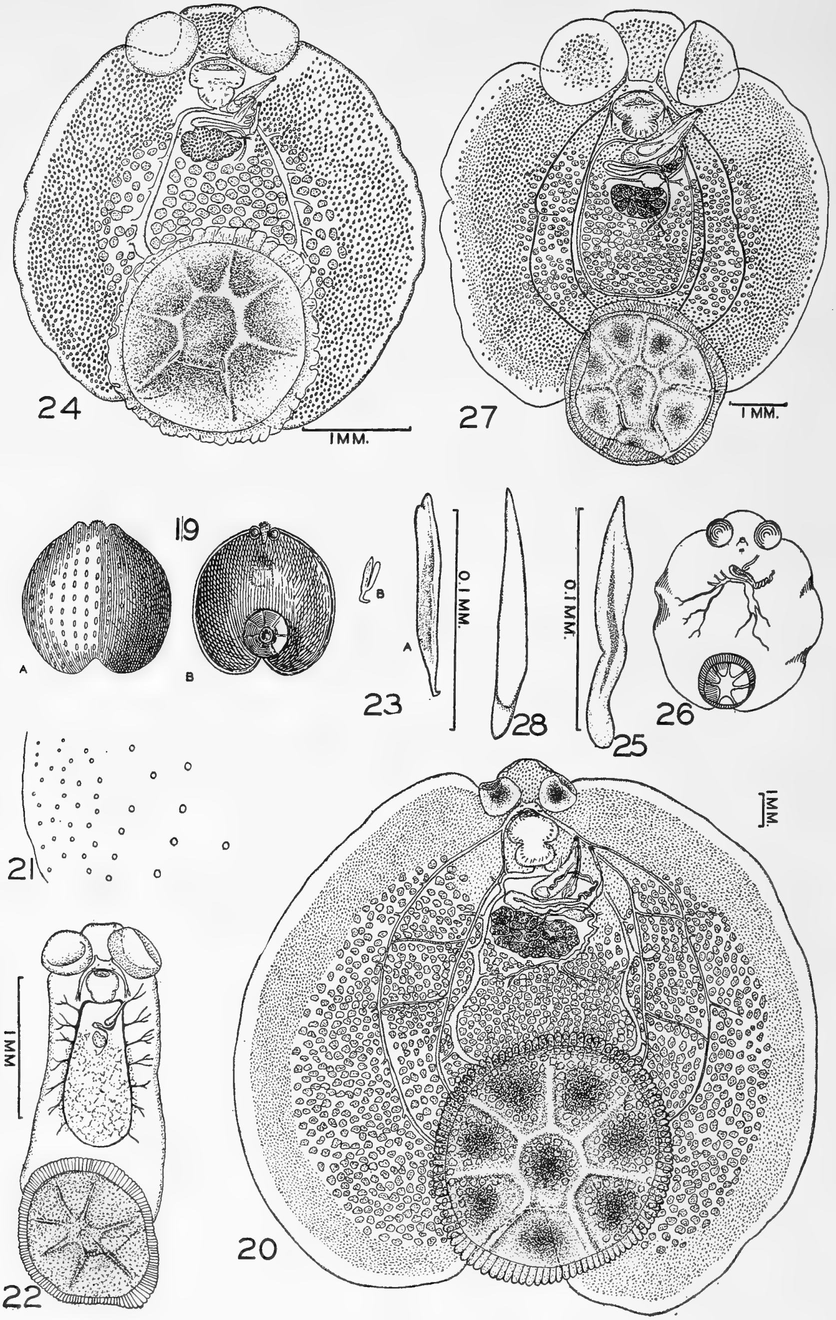
Host.—*Euthynnus alletteratus* (Rafinesque).

Location.—Gills.

Distribution.—United States (Woods Hole, Mass.).

Type specimen.—U. S. N. M. Helm. Coll. No. 35644.

This species is represented by a single immature specimen collected by G. A. MacCallum, July 20, 1915, at Woods Hole, Mass., from "*Thunnus thynnus*—Horse mackerel." The species is regarded as new on the basis of the large haptoral hooks, the free tips being hooked instead of straight or slightly curved as in the other species. The papillate condition of the ventral surface of the haptor suggests a relationship with *C. onchidiocotyle,* described by Setti (1899) from a "tonno" in Italy, and it is possible that the two spe-



Figs. 19–21.—*Capsala martinieri.* 19, complete worm (A—dorsal view, B—ventral view) after La Martinière (1797?); 20, ventral view, original; 21, diagram showing distribution of dorsal marginal spines; Figs. 22–23.—*C. maccallumi.* 22, complete worm, ventral view; 23, haptoral hooks (A—large hook, B—marginal hooklet); Figs. 24–25.—*C. lintoni.* 24, complete worm, ventral view; 25, large haptoral hook; Figs. 26–28.—*C. laevis.* 26, complete worm, after Verrill, 1885; 27, ventral view of type specimen, original; 28, large haptoral hook.

cies may be identical; however, since Setti's description is lacking in essential details, it appears necessary to regard the two forms as distinct until a restudy of *C. onchidiocotyle* is possible.

Capsala lintoni, n. sp. Figs. 24–25

Synonym.—*Tristoma laeve* Verrill of Linton, 1898.

Description.—Body outline almost circular, 3.7 mm long by 3.5 mm wide, deeply notched posteriorly; dorsal and ventral surfaces without papillae. Anterior haptors circular, about 600μ in diameter; posterior haptor about 1.6 mm in diameter, surrounded by a more or less pleated membrane 85μ wide. Central area of posterior haptor an irregular heptagon with 7 ridges or septa radiating from it as in other species of genus; ventral surface of haptor covered with papillae. Hooks blade-like, slightly sinuous, about 115μ long; marginal hooklets present, about 20μ long. Oral aperture median, slightly anterior to level of posterior margins of anterior haptors; pharynx constricted, 510μ long by 595μ wide; intestinal tract as in other species of genus. Genital aperture at level of middle of pharynx and a short distance from posterior margin of left anterior haptor. Cirrus pouch club-shaped, its base in contact with posterior end of pharynx. Testes numerous, occupying interintestinal field and extending for a short distance into extraintestinal fields. Ovary lobulated, about 340μ long by 510μ wide, median, about 510μ posterior to base of pharynx. Vitelline follicles extending to near margins of body and into cephalic lobe and anterior haptors. Vagina muscular, its aperture postero-median of genital aperture. Ootype immediately posterior to base of cirrus pouch. Eggs not observed.

Host.—*Gymnosarda pelamis* (Linnaeus).

Location.—Gills.

Distribution.—United States (Atlantic Ocean, south of Martha's Vineyard, Mass.).

Specimen.—U. S. N. M. Helm. Coll. No. 4878 (type).

This species is based on a single, somewhat immature specimen described by Linton (1898) as probably *Tristoma laeve* Verrill. The specimen was not in the best possible condition for study, being very dark and contracted. However, enough detail could be made out to show that it is distinct from *C. laevis* (syn., *T. laeve*), although closely related to that species. The chief differences between the two species are absence of dorsal marginal spines, and of papillae from the ventral surface of body, in *C. lintoni*. There is also a difference in the proportional sizes of the haptors; in *C. laevis* the ratio of the diameter of the anterior haptors to that of the posterior haptor is about 1:1.5, while in *C. lintoni* the ratio is about 1:2.6.

Capsala laevis (Verrill, 1875) Johnston, 1929

This species as originally described by Verrill (1875) was unrecognizable; it was later figured by Verrill (1885) but no specific details were shown. A redescription of this form has recently been given by the writer (Price, 1938), the redescription being based on specimens collected by Fr. Gunther in São Paulo, Brazil. The Brazilian specimens were compared with the type (U. S. N. M. No. 7179) and found to agree in all essentials; a further consideration of this species, therefore, appears unnecessary. However, figures (Figs. 26–28) of the type specimen are included for comparison with other American species.

Genus TRISTOMA Cuvier, 1817

Synonym.—*Capsala* Bosc, 1811; in part.

Diagnosis.—Dorsal marginal spines present or absent; when present, in numerous short transverse rows of similar or dissimilar spines. Posterior septa of haptor not bifid distally; large hooks when present, without claw-like tips. Pharynx globular or subglobular, never with constriction. Testes numerous, confined to interintestinal fields.

Type species.—*Tristoma coccineum* Cuvier, 1817.

The genus as present constituted contains four species as follows: *Tristoma coccineum* Cuvier, 1817, from *Xiphias gladius* and *Sphyrna zygaena* (new host); *T. integrum* Diesing, 1850, from *X. gladius; T. levinsenii* Monticelli, 1891, from *Thynnus* sp.; and *T. uncinatum* Monticelli, 1889, from ?*Pleuronectes* sp. The first two of these species occur on North American hosts and descriptions of them are included in this paper.

Tristoma coccineum Cuvier, 1817 Figs. 29–32

Synonyms.—*Tristoma papillosum* Diesing, 1836; *Capsala papillosa* (Diesing, 1836) Nordmann, in Lamarck, 1840.

Description.—Body bluntly oval, 10 to 12 mm long by 7 to 9.5 mm wide, convex dorsally and concave ventrally. Dorsal surface, especially of postovarial region, covered with prominent papillae, and with 43 to 54 rows of marginal spines, each containing from 2 to 4 spines; innermost spine 1-cuspid, second and third spines 2- to 7-cuspid, and outermost spine comb-like. Anterior haptors more or less circular, sucker-like, 1.27 to 1.69 mm in diameter. Posterior haptor disc-like, 1.8 to 2.38 mm in diameter, provided with marginal membrane 170 to 365μ wide, posterior margin not reaching posterior end of body; central area of haptor a complete heptagon with 7 septa radiating from it as in related species; large hooks straight, 133 to 152μ long; marginal hooklets 15μ long. Oral aperture median, slightly prepharyngeal, at or slightly anterior to level of posterior margins of anterior haptors. Pharynx almost globular, 1 to 1.3 mm long by 1.1 to 1.5 mm wide; intestine as in related species. Genital aperture slightly posterior to left anterior haptor. Cirrus pouch club-shaped, its base lying to left of median line posterior to pharynx. Testes numerous, confined to interintestinal field. Ovary lobulate, 680 to 795μ long by 1.1 to 1.59 mm wide, median, about 500 to 700μ posterior to pharynx. Vitelline follicles largely in extraintestinal fields except for relatively few follicles along course of median intestinal diverticula. Vagina slender, its proximal end expanded to form a seminal receptacle; vaginal aperture about 1 mm posterior to genital aperture. Ootype ovoid, to left of median line; metraterm slender. Eggs 114μ long by 95μ wide, more or less triangular and with 4 prolongations.

Hosts.—*Xiphias gladius* Linnaeus and *Sphyrna zygaena* (Linnaeus).

Location.—Gills.

Distribution.—United States (Woods Hole, Mass.).

Specimens.—U. S. N. M. Helm. Coll. Nos. 4877, 7168, 35124, 35645, 35646 and 35647.

In attempting to trace the synonymy of *Tristoma coccineum,* a complication has arisen which appears to necessitate questioning the validity of the species generally regarded as *T. coccineum* and *T. papillosum.* The situation is briefly as follows:

Cuvier (1817) erected the genus *Tristoma* for certain ectoparasitic flukes occurring on *Mola mola* and *Xiphias gladius,* and in this description he named one species, *T. coccineum;* the description was illustrated by a rather diagrammatic figure. This description is as follows:

> "*TRISTOME. (TRISTOMA. CUV.)*"
>
> Leur corps est un disque large et plat; à sa face inférieure est en avant un grand suçoir cartilagineux, que ne tient au corps par un court pédicule, et sous son bord postérieur s'en trouvent deux petits. Dans le parenchyme du corps rampe un vaisseau circulaire ramifié dont la nature est difficile à déterminer.
>
> Une espèce d'un pouce et plus de largeur, colorée en rouge vif (*tristoma coccineum.* Cuv.), s'attache aux branchies de plusieurs poissons de la Méditerranée, tels que la *môle,* le xiphias, etc.

In this description the anterior end of the body was mistaken for the posterior end but this error was corrected in a later description (Cuvier, 1847).

From our present knowledge of the tristomes it is clear that at least 2 species were confused under the name *T. coccineum,* one from *Mola mola,* later described as *T. molae* by E. Blanchard (1847), and the other from *Xiphias gladius,* which was either the *T. coccineum* of authors or the species later described by Diesing (1836) as *T. papillosum.* Unfortunately, however, Cuvier's description is so general that it is of little value and the identity of his *T. coccineum* rests mainly upon the figure which accompanies it. This figure shows that the form which he selected could not have been from *Mola mola* but was one of the species from the sword fish, since the form from *Mola mola* is more or less cordate in shape and the posterior haptor relatively large as compared with the length of the body; the posterior end of the body of the species from *M. mola* also shows a deep notch. In the species figured by Cuvier the body was longer than wide, the posterior haptor relatively small as compared with the length of the body and no posterior notch was shown. These details eliminate E. Blanchard's *T. molae* from further consideration.

In 1826, Risso added to the description of *T. coccineum* as given by Cuvier the following: "Aux caractères donnés par M. Cuvier j'ajouterai que la partie supérieure de ce tristome est munie de petits tubercules blancs, contractiles su gré de l'animal, et que son suçoir est blanchâtre."

Later, Diesing (1836) described as *T. papillosum* a species from *Xiphias gladius,* which was provided with tubercles or papillae on its dorsal surface, a condition which corresponded to Risso's (1826) observation of the form which he regarded as *T. coccineum.* Previous to describing *T. papillosum,* Diesing (1836) redescribed *T. coccineum,* but the species he had was the one from *Mola mola*, and very clearly the species which E. Blanchard described as *T. molae*.

The most complete accounts of the two species from *Xiphias gladius* are those given by Taschenberg (1879) who described as *T. coccineum* a form almost circular in shape and bearing on its dorsal surface, along the lateral margins numerous, short, closely approximated, transverse rows of similar spines, while *T. papillosum* was described as a form longer than wide, with the dorsal marginal spines in less numerous rows, each row composed of dissimilar spines. Subsequent writers have adhered to the descriptions of these species as given by Taschenberg.

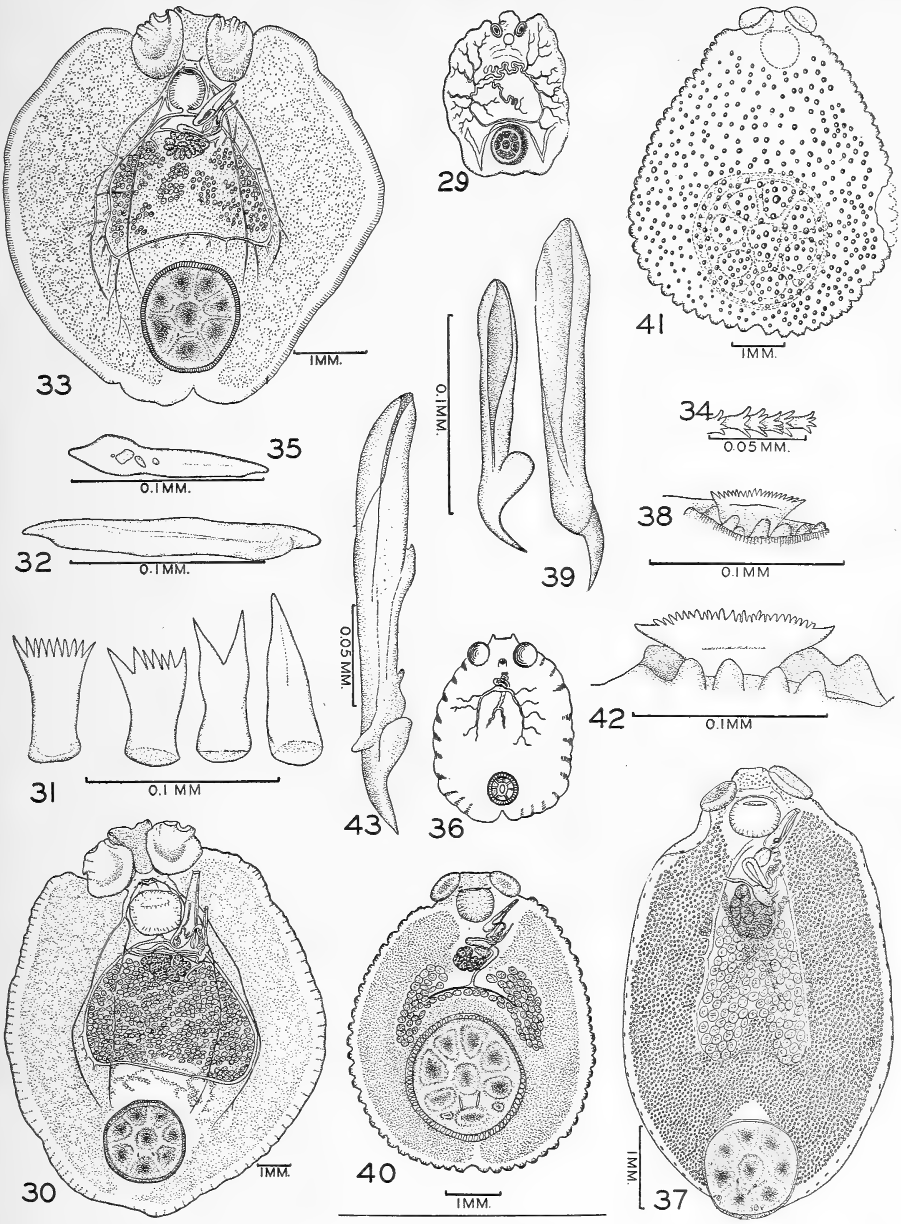
From the above review of the pertinent facts bearing on the identity of *T. coccineum*, it appears that in view of the illustration given by Cuvier and the addition to the description given by Risso, both in agreement with the form now generally known as *T. papillosum* Diesing, *T. papillosum* must fall as a synonym of *T. coccineum* Cuvier, and the species described by Taschenberg as *T. coccineum* must be regarded as a separate species and take the oldest available synonym which is *Tristoma integrum* Diesing.

Tristoma coccineum (syn. *T. papillosum* of authors) is the most abundant species occurring on the sword fish. It is apparently quite host specific and probably occurs rarely on hosts other than *Xiphias gladius*. All of the specimens of this species in the United States National Museum Collections, with the exception of 1 specimen in the MacCallum collection from the hammer-head shark, *Sphyrna zygaena*, are from *Xiphias gladius*. The fact that this parasite occurs so rarely on hosts other than the sword fish makes the reported occurrences of this species from *Mola mola* doubtful.

Tristoma integrum Diesing, 1850 Figs. 33–35

Synonyms.—*Tristoma coccineum* Cuvier, 1817, in part; *T. coccineum* Cuvier, of Taschenberg, 1879 and of subsequent authors; *T. rotundum* Goto, 1894.

Description.—Body more or less circular, 575μ to 7 mm long by 6 to 6.5 mm wide. Dorsal surface convex, without papillae, with numerous transverse rows (more than 300 in one specimen) of spines along lateral margins, usually 6 spines to each row, the number per row diminishing towards the anterior and posterior ends of body. Spines similar, 3- to 5-, usually 4-cuspid, about 20 to 26μ long by 11μ wide at base. Ventral surface concave, smooth. Anterior haptors somewhat elliptical, 850 to 935μ long by 765 to 850μ wide. Posterior haptor disc-like, 1.4 to 1.6 mm in diameter, surrounded by a pleated membrane about 300μ wide; ventral surface without papillae; central area a regular heptagon with 7 septa radiating from it as in related species; large hooks blade-like, 110 to 133μ long, marginal hooklets 15μ long. Oral aperture median, slightly anterior to level of posterior margins of anterior haptors. Pharynx more or less globular, without constriction, about 510μ in diameter. Intestine as in other species of genus; anterior branches not extending into anterior haptors. Male genital aperture immediately posterior to margin of left anterior haptor. Cirrus pouch club-shaped, its base lying posterior to pharynx and slightly to left of median line. Testes numerous, confined to interintestinal field. Ovary lobulate, 255



Figs. 29–32.—*Tristoma coccineum.* 29, complete worm, after Cuvier, 1817; 30, ventral view, original; 31, dorsal marginal spines; 32, large haptoral hook; Figs. 33–35.—*T. integrum.* 33, ventral view; 34, dorsal marginal spines; 35, large haptoral hook; Figs. 36–39.—*Capsaloides cornutum.* 36, complete worm, after Verrill, 1885; 37, ventral view, original; 38, dorsal marginal spines; 39, large haptoral hooks; Figs. 40–43.—*Capsaloides magnaspinosus.* 40, ventral view; 41, dorsal view; 42, dorsal marginal spine; 43, large haptoral hook.

to 370μ long by 680 to 765μ wide, median, about 400μ posterior to pharynx. Vitelline follicles largely in extraintestinal fields except for few follicles along course of median intestinal branches, extending into cephalic lobe but not into anterior haptors. Vagina slender, opening postero-median of genital apertures. Ootype immediately posterior to cirrus punch; metraterm slender, opening, according to Taschenberg (1879) and Goto (1894), immediately posterior to male aperture; opening not observed by the present writer. Egg more or less triangular, 90μ wide, with 4 prolongations.

Host.—*Xiphias gladius* Linnaeus.

Location.—Gills.

Distribution.—United States (Woods Hole, Mass.).

Specimens.—U. S. N. M. Helm. Coll. No. 35299.

This species apparently is quite rare on the sword fish, *Xiphias gladius*, from American waters, as only 2 specimens were found in the collections of the United States National Museum, in spite of the fact that a number of lots of specimens of *T. coccineum* (syn. *T. papillosum*) were available from that host. Both of these specimens of *T. integrum* were collected July 9, 1913, by G. A. MacCallum at Woods Hole, Mass.; the above description is based on these specimens. This description corresponds in general to that given by Taschenberg (1879) and by Goto (1894), except that the specimens available were considerably smaller than those described by Taschenberg and by Goto, the size given by the former being 17 mm long by 19 mm wide and that by the latter 11.5 mm long by 13 mm wide.

The most outstanding differences between *T. integrum* and *T. coccineum* are in the number of rows of dorsal marginal spines, and in the morphology of these spines. The rows of spines on *T. integrum* are very numerous (more than 300 on each side of the body in one specimen) and the spines in each row are similar in form. There are fewer rows of spines on *T. coccineum* (43 to 54 in the specimens examined) and the spines are dissimilar; the most median spines have only 1 cusp, the outermost spine has 10 or more cusps, and the others have from 2 to 7 cusps.

Genus CAPSALOIDES Price 1938

Synonyms.—*Capsala* Bosc, 1811, in part; *Tristoma* Cuvier, 1817, in part; *Calsaloides* Price, 1936 (printer's error).

Diagnosis.—Dorsal marginal spines present, crown-like, in a single longitudinal row. Posterior septa of posterior haptor bifid distally; large hooks with claw-like tips. Pharynx globular or subglobular, never with constriction. Testes numerous, forming a W-like pattern, confined to interintestinal field.

Type species.—*Capsaloides cornutum* (Verrill, 1875), Price, 1938.

Four species are included in the genus *Capsaloides* as follows: *Capsaloides cornutum* (Verrill, 1875), from *Tetrapturus imperator; C. magnaspinosus*, n. sp., from *T. imperator; C. sinuatum* (Goto, 1894), from *Histiophorus* sp.; and *C. perugiai* (Setti, 1898), from *Tetrapturus belone*. Only first two of these are from North America.

Capsaloides cornutum (Verrill, 1875) Price, 1938 Figs. 36–39

Synonyms.—Tristoma cornutum Verrill, 1875; *Capsala cornuta* (Verrill, 1875) Johnston, 1929.

Description.—Body elongate oval, 5.3 to 8 mm long by 3.8 to 6 mm wide, dorsal and ventral surfaces covered with minute papillae, margins entire or slightly sinuate. Dorsal marginal spines crown-shaped, 38 to 76μ wide, arranged in a single row of 21 spines on right side and 26 on left; anterior spines on left side smaller than others, in a group of 4 to 6, and separated from larger spines by a relatively wide space at level of genital aperture. Anterior haptors sucker-like, 595 to 850μ in diameter. Posterior haptor disc-like, 1.19 mm in diameter, surrounded by a festooned marginal membrane about 85μ wide, sometimes projecting slightly beyond posterior margin of body. Central area of posterior haptor an irregular heptagon with 7 ridges or septa radiating from it; each of the posterior septa bifurcating distally and enclosing a small triangular lacuna. Large hooks 133 to 178μ long, tips claw-like and slightly curved; marginal hooklets 14 in number, 15μ long. Oral aperture median, slightly anterior to level of posterior margins of anterior haptors. Pharynx more or less globular, 434 to 510μ long by 510μ to 595μ wide; intestine as in related species. Common genital aperture slightly posterior to margin or left anterior haptor, about midway between body margin and pharynx. Cirrus pouch club-shaped, its base lying to left of median line at posterior margin of pharynx. Testes numerous, in interintestinal field, forming a pattern suggestive of the letter W. Ovary lobulated, 340μ long by 680μ wide, median, pretesticular. Vitelline follicles largely in extraintestinal fields. Vagina slender, opening at level of ootype and ventral to left intestinal branch. Ootype large, oval, postero-median of base of cirrus pouch; metraterm slender. No eggs observed.

Host.—Tetrapturus imperator (Bloch and Schneider).

Location.—Gills.

Distribution.—United States (Block Island, and Woods Hole, Mass.).

Specimens.—U. S. N. M. Helm. Coll. Nos. 7178 (type) and 35136.

In 1875, Verrill described an ectoparasitic trematode which he named *Tristoma cornutum* as follows:

> Body thin, broad elliptical, or oblong emarginate posteriorly; anterior end narrowed, produced, and with a short, tapering, tentacle-like process at each angle; upper surface with minute rounded granules and small scale-like wrinkles; smooth beneath. Posterior sucker small, less than one fourth breadth of the body, its border divided into much fewer and larger teeth than in the preceding species [*T. laeve*]; anterior suckers two thirds as broad as the posterior, nearly two diameters apart.
>
> Color light red or flesh color.

Neither the host name nor an illustration of the species accompanied the description. Later Verrill (1885) gave a rather diagrammatic figure of the species and stated that the host was *Tetrapturus albidus* (= *T. imperator*). Owing to the incompleteness of the description and figure the species has not been identifiable, and up to the present time no additional reports of its occurrence have been made.

In going over the monogenetic trematodes in the Helminthological Collection of the U. S. National Museum, 1 specimen (U. S. N. M. 7176) labelled

"*Tristoma cornutum* Verrill, type, gill of bill fish, Block Island" was found, and in the MacCallum collection there were several specimens (U. S. N. M. 35136) labelled "*Tristomum coccineum*, gills, Spear fish—*Tetrapturus imperator*," which proved to be the same species as that described by Verrill as *T. cornutum*. The type specimen was not in good condition, but sufficient detail could be made out to show that the specimens collected by MacCallum were *T. cornutum*. The above description is based largely on the specimens collected by MacCallum.

There are several characters which *Tristoma cornutum* shares with certain other members of the family; these seem to be constant and for that reason the genus *Capsaloides* was proposed to include *Tristoma sinuatum* Goto, *T. perugiai* Setti, and *T. cornutum*, the latter being designated as type; to this genus is also added *C. magnaspinosus*, n. sp. The species described as *T. papillosum* Diesing by Kölliker (1849) also belongs in this genus, but whether it represents a distinct species or is identical with one of the other species included in the genus *Capsaloides* cannot be determined from the original description; it bears considerable resemblance to *C. cornutum*, but may possibly be identical with *C. perugiai* which was described from the same host as Kölliker's *T. papillosum*.

Capsaloides magnaspinosus n. sp. Figs. 40–43

Description.—Body oval to piriform in outline, 5.4 to 6.6 mm long by 4.6 to 5.3 mm wide. Dorsal surface covered with relatively large, wart-like papillae about 85μ in diameter; ventral surface smooth. Margins of body serrate, each projection bearing dorsally a crown-shaped spine 95 to 125μ wide; about 30 spines on each side, each spine set in a depression bearing a number of small papillae on its margins. Anterior haptors sucker-like, oval, 425μ by 595 to 680μ. Posterior haptor 2.1 to 2.38 mm in diameter, surrounded by a festooned marginal membrane about 510μ wide; posterior margin of haptor not reaching posterior end of body. Central area of haptor an irregular heptagon with 7 septa radiating from it as in other tristomes; each of the posterior septa bifurcates distally and encloses a small triangular lacuna. Large hooks 161 to 311μ long, tips claw-like and curved; marginal hooklets (?)14 in number, about 15μ long. Oral aperture median, near level of posterior margins of anterior haptors. Pharynx globular, 510μ to 1 mm long by 730μ to 1.19 mm. wide. Intestine as in other tristomes. Common genital aperture near posterior margin of left anterior haptor. Cirrus pouch club-shaped, its base at median line posterior to pharynx. Testes numerous, in 2 lateral groups connected medially, forming a W-shaped pattern, confined to interintestinal field. Ovary lobulate, median, 510 to 850μ long by 680μ to 1.02 mm wide, about midway between posterior end of pharynx and connecting band of testes. Vitelline follicles occupying greater part of body except for portions occupied by other organs. Vagina slender, opening some distance posterior to genital aperture. Ootype oval, posterior to base of cirrus pouch; metraterm slender. Eggs not observed.

Host.—*Tetrapturus imperator* (Bloch and Schneider).

Location.—"Nares."

Distribution.—United States (Woods Hole, Mass.).

Specimens.—U. S. N. M. Helm. Coll. No. 35648 (type and paratypes).

This description is based on 3 specimens collected "ex nares" of *Tetrapturus imperator*, by G. A. MacCallum, July 25, 1924, at Woods Hole, Mass. *Capsaloides magnaspinosus* is easily distinguished from all other species by the relatively large posterior haptor and by the size of the dorsal marginal spines, which are very large as compared with those on other species of the genus. The dorsal papillae are quite prominent and much larger than those of *C. cornutum* (Verrill).

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GEOLOGY.—*Our petroleum supply.*[1] Hugh D. Miser, U. S. Geological Survey.

The petroleum supply of the United States is of great importance, whether we express the volume and value of the annual output in barrels or dollars, or measure the service of petroleum in terms of human welfare and progress.

Petroleum is produced in many countries, and its products are used in factories, on highways, and in homes in all lands. Although the petroleum industry thus encircles the earth, it is outstandingly an American industry. The drilling of wells for oil in the United States began in 1859. Our country leads in the development of the industry, and it produces and consumes three-fifths of the world's annual output. Also, the United States possesses about half of the world's known reserves of petroleum.

PRESENT PRODUCTION AND USES OF PETROLEUM IN UNITED STATES

Our domestic petroleum production is obtained from about 360,000 wells in 22 States; only a small part—about 5 per cent—of our domestic consumption is imported from other countries.

The value of our petroleum output for 1937 measured in dollars is one-fourth the value of the entire annual mineral production of the United States. It exceeds the total value of all the metallic mineral products combined for that year. The next mineral product in point of value is coal, the next is iron, and then follows natural gas.

Chief among the many uses of petroleum is the production of power. Such power drives our 30,000,000 motor vehicles on the land, our Navy on the ocean, and our planes in the air. Altogether, one-third the mechanical energy produced in the United States comes from petroleum and its companion mineral product, natural gas.

Our domestic production through 1937 totals 19,972,000,000 barrels. Texas stands first, having produced 5,127,000,000 barrels, a

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[1] Address of the retiring president of the Geological Society of Washington, delivered December 14, 1938. Published by permission of the Director, Geological Survey, United States Department of the Interior. Received December 15, 1938.

quarter of all the Nation's output of oil. California has produced 4,872,000,000 barrels, 24 per cent, and Oklahoma 4,341,000,000 barrels, 21 per cent. The output of no other State has equaled the domestic demand of petroleum products for the year 1937—namely, 1,169,000,000 barrels.

Altogether, Texas, California, and Oklahoma have contributed 72 per cent of all the oil output of the United States. The total production of each of these States is greater than that of the U.S.S.R.—3,771,000,000 barrels through 1937—which ranks next to the United States in point of cumulative production. Mexico ranks third in total world output, with 1,863,000,000 barrels, and Venezuela fourth, with 1,491,000,000 barrels. No other oil-producing country has produced as much as one billion barrels.

The principal petroleum products and their uses form long lists whose presentation time does not now permit. A general grouping of the refined products includes gasoline, kerosene, fuel oils, lubricants, paraffin wax, petroleum coke, asphalt, road oil, petrolatum, absorption oil and medicinal oil.

Kerosene, the first petroleum product to be utilized in important quantities, is still extensively used for lighting. In addition, it is utilized in increasing volumes to provide power and heat.

The domestic demand for gasoline in 1937 was 519,000,000 barrels, for use chiefly in our motor vehicles. The automobile depends heavily on the petroleum industry; it consumes 89 per cent of our gasoline, 40 per cent of our lubricants, and requires natural gas derived carbon black which lengthens 2½ to 3 times the lifetime of our tires. The domestic demand for gasoline is directly related to the number of motor vehicles, which average one to about every five persons. The volume of consumed gasoline, since the introduction of the first American automobile in 1892, parallels the increasing numbers of motor cars. In late years the slight departure from parallelism is due to the greater volume of gasoline used by each car and to the increased use of gasoline in airplanes, tractors, motor boats, and stationary engines. Second only to gasoline were the requirements for fuel oil—442,000,000 barrels in 1937—which is used by railroads, steamships, gas and electric power plants, mines, smelters, manufacturing plants, oil companies, and U. S. Navy, and for domestic heating. The development of our machine age has depended on a plentiful supply of lubricants made from petroleum. The great volume of demand—23,323,000 barrels in 1937—can be met only by obtaining it from petroleum.

Our petroleum output, as thus briefly described, is provided by one of the Nation's most important industries. The investment in the United States in the five divisions—the producing, natural gasoline, transportation, refining, and marketing divisions—of the petroleum industry totals about $14,000,000,000.

EARLY DEVELOPMENT AND USES OF PETROLEUM

Before 1859 petroleum and its associated hydrocarbons had been used by the peoples of many lands for at least several thousand years before the Christian era. Seepages and hand-dug pits and shafts provided the entire supply of these materials, except in India and China where oil was obtained from drilled wells. The Chinese, by sinking wells to depths of 1,500 to 2,000 feet for brine, oil, and gas, were recognized as the ancient world's most accomplished well drillers.

The early uses for petroleum and its products were many, as will be noted below.

Asphaltic pitch was used to waterproof the ark of Noah, the cradle of Moses, and the cisterns and silos of ancient Egypt and Mesopotamia. Also, it was used by the Egyptians in the process of mummification. Asphalt was used as a mortar in the construction of Nineveh and Babylon and also in the buried cities of Ur, as early as 4000 B.C. Oil from Sicily was used by the Romans to light the temple of Jupiter, and many centuries later flame throwers fed by naphtha were employed against the Crusaders when they stormed the walls of Constantinople. Petroleum was distilled into products of commerce at Baku as early as the 18th century; oil was there used in lamps and also was utilized for cooking in 1723. In Rumania the exploitation of oil by shafts dates as far back as the second half of the 16th century. To Rumania is ascribed the first recorded volume of output of crude petroleum. In 1857 that country produced 1,977 barrels and since then it has an unbroken record of production.

The early American Indians were familiar with natural petroleum seepages. They set their mosaics in asphaltum; they used it as an adhesive substance; they lined their baskets with it; and they had great faith in petroleum for performing all manner of cures.

Oil and gas were known and used before 1859 in many other countries. A search and study of the literature concerning their recovery, transportation, treatment, and utilization before that date reveals a fascinating story of the progress of human civilization.

At the beginning of the 19th century, when the supply of whale oil for lighting needs was dwindling, the world was faced with the necessity of finding a reasonably priced substitute for it. This necessity stimulated the research—already being conducted—in the distillation of oil from coal and shale. Paraffin was extracted from both bituminous shale and crude petroleum in France in 1830. Burning oil in commercial quantity was first produced from shale in France in 1838. The refining of oil at the Riddings Colliery in Derbyshire was begun in 1848 by James Young and he later obtained oil from coal and bituminous shales. He founded in 1851 the Scotch industry for the extraction of oil and paraffin from boghead coal. His process for obtaining illuminating oil was rewarded with commercial success, and during the next 10 years its use expanded rapidly in Great Britain and was introduced into the United States. American coals were treated in plants in Pennsylvania, West Virginia, Kentucky, and Ohio. This rising industry was soon replaced by the petroleum industry.

During the first half of the 19th century increasing quantities of crude petroleum, known as rock oil, were obtained from seepages and from wells drilled for salt brines in Pennsylvania, Ohio, Kentucky, and West Virginia, but very little of it was marketed. Between 1850 and 1855 petroleum from a salt well at Tarentum, Pa., was refined in Pittsburgh and sold for lamp use. Also by 1850 some oil from the locality was bottled and sold by druggists; and about 1855 the oil was refined by methods used for the recovery of oil from coal.

The salt wells in Pennsylvania and the nearby States had been drilled with equipment designed for the purpose. This equipment, which embodied the fundamental features of the modern standard cable drill rig, was developed in 1806–1808 in the Kanawha Valley, West Virginia. Accordingly, salt well drillers and their equipment were employed for the drilling in 1859 of the Drake well near Titusville, Pa., in which it was hoped that there would be obtained a larger supply of oil than that afforded by the oil springs of the locality. The Drake well, on reaching a depth of $69\frac{1}{2}$ feet, discovered oil and its initial daily output was 25 barrels. This was America's first commercial oil well.

RELATION OF GEOLOGY TO PETROLEUM INDUSTRY

The phenomenal growth of the petroleum industry in the United States has been aided greatly by engineering and science. In the words of W. C. Teagle, formerly President of the Standard Oil Co. of New Jersey, "The operation of the world's oil industry is now very largely in the hands of technical experts, geologists, physicists, chemists, and engineers. This change in the complexion of the responsible operating personnel has occurred more rapidly, perhaps, than in any other field of comparable importance (17)." On the same subject Lord Cadman, head of many British petroleum companies and past president of the Institution of Petroleum Technologists, comments, "In no branch of human endeavor has the application of exact knowledge been so apparent as in the exploring, winning, refining, transport, distribution, and utilization of mineral oil. At every point in the long road that leads from the oil well to the consumer investigation and research have been employed with almost spectacular results (2)."

The recognition of the value of the geologists' contribution to the industry finds concrete expression in the fact that most of the companies have geological departments. Oil companies, however, have employed great numbers of geologists only in the last 25 years.

The general acceptance of geology in the search for oil took place about 1915, more than 50 years after the completion of the Drake well. This acceptance was not so much a whole-hearted welcome as it was a necessity, for the oil companies were being pressed to meet the rapidly increasing demands for gasoline required for the growing numbers of motor vehicles.

Although geology was utilized only to a limited extent in the selection of drilling sites during the first half century of the petroleum industry, geologic observations concerning the occurrence of petroleum date back to 1842. In that year William Logan observed the occurrence of oil on anticlines near Gaspé. In 1860 H. D. Rogers noted that the newly discovered fields in Pennsylvania were located on anticlines. In the following year T. Sterry Hunt outlined the first clear statement of the anticlinal theory of the accumulation of petroleum but during the next 25 years Hunt and the other geologists who accepted the anticlinal theory made little application of it in reporting on the oil possibilities of certain areas in the United States and Canada. In the early eighties I. C. White made practical application of the principles of the theory in the location of new oil and gas fields, but still the industry in general continued to ignore geology. From 1900 to 1915 the significance of the relation of petroleum to anticlinal structure was clearly demonstrated for many areas by the investigations and publications of the Federal Geological Survey.

The number of geologists now serving the industry in the United States, in the employ of companies and in the employ of Governmental, State, and other institutions, appears to exceed 3,000—a number somewhat larger than the number of geologists in the United States who are members of the American Association of Petroleum Geologists. Altogether, 2,354 geologists living in the United States were members of this organization on March 1, 1938.

It is noteworthy that the States having the greatest oil production are the ones that have most oil geologists, as indicated by the membership of the American Association of Petroleum Geologists as of March 1, 1938.

Texas, ranking first in production—510,318,000 barrels of oil in 1937 has . . . . 868 geologists
California, standing second—238,521,000 barrels of oil in 1937—has . . . . 314 geologists
Oklahoma, standing third—228,839,000 barrels of oil in 1937—has . . . . 430 geologists
Louisiana, standing fourth—90,924,000 barrels of oil in 1937—has . . . . 124 geologists
Kansas, standing fifth—70,761,000 barrels of oil in 1937—has . . . . 134 geologists

In these five States there is one geologist for every 600,000 barrels of oil produced in 1937.

METHODS EMPLOYED BY THE PETROLEUM GEOLOGIST

The oil geologist, in the application of his science to the recovery of petroleum, has a wide field of opportunity before him and he makes use of facts and conclusions from many phases of geology, including structure, stratigraphy, paleontology, sedimentary petrology, sedimentation, geomorphology, and metamorphism. In his search for, and his location of, oil deposits he has from time to time abandoned or modified old methods and has adopted new methods of exploration. The available time will not permit the presentation of a full list of these methods; it will permit no more than brief mention of some major developments during the present century. Important developments during the early years of the century were the adoption of the structure contour to portray the structural features of prospective or producing oil and gas areas and also the application of the plane table and alidade as instruments for determining accurately the altitudes of the "key beds" that were contoured.

Aeroplane photography, first employed during the World War, was utilized about 1920 by the oil geologist. Subsequently its utilization by Governmental agencies and by oil and other companies has increased rapidly, and at present about half the area of the United

States has been covered by aerial photographs. To the geologist such photographs record a wealth of essential details of geologic features that are not obtainable by any other method of mapping. As the years pass, he relies more and more on such pictures and employs fewer and fewer plane table maps.

Surface structural mapping reached its peak application between 1920 and 1925, and it has thus for many years occupied a place of decreasing importance in the search for new oil fields. This decline is attributable to the gradual decrease in number of favorable structural features that can be recognized by surface geologic mapping.

Core drilling for the determination of structure was introduced in the United States in 1919 and was employed on an extensive scale for many years in portions of the Mid-Continent region.

The microscopic examination of well cuttings was begun on a large scale in 1917 and since that time it has reached a place of fundamental importance. To it the oil geologist now gives about half of his effort. The practice of obtaining cores of oil sands and other important beds in order that their character may be accurately noted is used in all producing areas. The microscopic study of insoluble residues obtained by dissolving in hydrochloric acid well cuttings of limestones and dolomites was begun in 1924 by H. S. McQueen (9). It has been successfully utilized by the oil industry in the Mid-Continent region —from Ohio and Tennessee on the east to Kansas and New Mexico on the west—for the determination of underground stratigraphy and structure.

Micropaleontology, first introduced in universities and also by companies to a limited extent as early as 1919, became an integral part of the oil business in the United States in 1924.

Geophysical methods, magnetic, gravimetric, electrical, and seismic, are widely used in the United States by the oil industry as a means for locating and mapping buried structural features. The adoption of the seismograph followed the discovery of its applicability during the World War for locating long range guns. In its use by the oil industry the long range guns are replaced by explosive charges in prospective oil localities. The first applications of gravimetric methods in the detection of anticlinal structure in this country were made in 1917 and 1919 by the Coast and Geodetic Survey when stations on Damon Mound, Texas, and Paleozoic folds in Maryland were occupied at the request of David White of the Geological Survey (21). In 1924 oil companies located three salt domes by geophysical methods, the Nash dome by means of the torsion balance, the Orchard dome by the seismograph, and the Long Point dome by both the torsion balance and the seismograph. Since 1924 a total of about 100 salt domes in the Gulf Coastal Plain and many other structural features from New York to California have been found by means of geophysical methods.

A type of well record or log, known as an electrical log, was developed in 1928. This type of well record is a great aid in exploratory drilling and the exploitation of oil fields. It shows the electrical resistivity and the relative porosity of the beds passed through by the drill. It permits the identification of oil- and water-bearing sands and gives useful information concerning the character of the beds. This information, in many areas, is more accurate than that provided by sets of cuttings.

PROGRESS OF PETROLEUM GEOLOGY

The progress of the science of petroleum geology is revealed in many publications, particularly those of the Federal and State Geological Surveys and the American Association of Petroleum Geologists. This Association was organized in Tulsa, Okla., in 1917 with a membership of 94 and now (December, 1938) has a domestic and foreign membership of about 3,000—a number greater than that of any other geological society in the world. The Association issues a monthly bulletin containing about 150 pages in each number, and in addition it has issued twelve special volumes. The reports of the Federal and State Geological Surveys dealing especially with petroleum geology are numerous and constitute a major portion of the literature on the subject.

An important factor in the development and progress of petroleum geology has been the mounting store of geologic data supplied by wells that have constantly increased both in number and depth. The number of wells that have been drilled for oil and gas in the United States exceeds 900,000. The world's deepest well, completed this year in the southern San Joaquin Valley, California, reached a depth of 15,004 feet. This well is nearly 9,000 feet deeper than the mine workings (slightly more than 6,150 feet) of the Quincy Mining Co., Hancock, Mich., and is about 6,500 feet greater than the 8,530-foot workings of one of the Crown Mines on the Rand. The producing zone of this deep California well is from 13,092 to 13,175 feet, but a more recently completed well of the Fohs Oil Co. in Terrebonne Parish, Louisiana, is producing from a slightly greater depth—namely, 13,254 to 13,266 feet.

CONTRIBUTIONS OF PETROLEUM GEOLOGY TO GENERAL SCIENCE OF GEOLOGY

Petroleum geology, because of its wide field of opportunity for the investigation of geologic conditions on the surface and also geologic conditions to the depths penetrated by wells—15,004 feet—and to the depths reached by geophysical methods—more than 30,000 feet—has made notable contributions to the general science of geology. Some of the more important contributions will be mentioned briefly.

Anticlines, as already noted, were first sought as favorable structural features on which to locate drilling sites for oil; but, with further drilling and the consequently increased knowledge of the occurrence of petroleum, it was learned that oil occurs not only on simple anticlines but also on many other types of structural features which include terraces, anticlinal noses, faults, unconformities, salt domes, lenticular sands, and buried hills.

Buried hills and the superposition of surface anticlines over them were brought to the attention of geologists by Sidney Powers (12) following the discovery of granite hills underneath the Eldorado line of folding in Kansas and of hills of Ordovician rocks underneath the Pennsylvanian sand production at Healdton, Okla.

Our knowledge of the geology of the salt domes in Louisiana and Texas has been revolutionized in the last quarter of a century. Now the domes are generally regarded as intrusive plugs of salt that moved upward from bedded salt of probable late Jurassic or early Cretaceous age. The salt is believed to have moved upward as much as 30,000 feet in the coastal portions of Louisiana and Texas. Formerly the salt masses were believed to have been formed as a result of volcanic activity, gas uplift, or the crystallization of the salt along zones of weakness in the rock strata.

The Gulf Coastal Plain may be cited as an example of an area whose tectonic map has undergone great transformation as the result of oil exploration. To the tectonic map of the Gulf Coastal Plain such structural trends as the Mexia fault zone, the buried course of the Ouachita belt of Paleozoic rocks, and the Gulf Coast geosyncline, have been added.

From the determination of the effect of regional structural deformation and the attendant metamorphism on deposits of petroleum and coal in the eastern United States David White drew, in 1915, a "deadline" beyond which oil may not be expected in the Appalachian and Ouachita regions (22). This oil "deadline," or extinction zone, lies between the 60- and 65-isocarbs, lines connecting points where the coals have 60 to 65 per cent of fixed carbon.

Also, the composition of the hydrocarbon gases in the northern Appalachian region bears a close relation to the structure and the degree of metamorphism of the associated strata. This has been pointed out recently by S. H. Hamilton (6), Charles R. Fettke (4), Paul H. Price (13), and A. J. W. Headlee (13).

From the measurements of the temperatures of deep wells by Van Orstrand (20) and others in the United States it has been shown that relatively high temperatures are generally associated with faults, salt domes, sand lenses, and anticlines of both large and small closure. It appears that both the local and regional variations of earth temperatures of the sedimentary strata thus penetrated by wells are related to thermal conductivity and to the depth to the underlying crystalline basement. Differential uplift on either a large or a small scale would tend to elevate the isotherms irregularly.

Stratigraphy, of a refined character, has received impetus in consequence of the requirements of the oil industry for exact information concerning the thickness and character of the rock strata of prospective oil regions and of areas under development. This type of information is required for an interpretation of geologic history and for the preparation of precise structure maps. The geologic history has a bearing on the origin and migration of oil and the structure maps may reveal favorable places for its accumulation.

Time will permit mention of only three interesting types of stratigraphic work. One of these is to be found in western Kansas where petroleum geologists have matched the intervals between bentonite beds in the Niobrara chalk in a way suggestive of the matching of tree rings by archaeologists in dating ancient pueblos in New Mexico and Arizona. In this way the geologists obtain extremely accurate data for mapping structure on the surface and in core drilling.

An investigation by N. W. Bass (1) and his coworkers of the shoestring sand bodies that yield much petroleum in Greenwood and Butler Counties, Kansas, and Osage County, Oklahoma, has shown that these elongated lenticular sand bodies represent sand bars along ancient shore lines during the Pennsylvanian epoch. A study of 22,000 well logs in and near the oil fields supplemented by an investigation of nearly the full length of the Atlantic and Gulf Coasts has made possible the mapping of land features and shore lines of the ancient seas as they existed in Kansas and Oklahoma 250 million years ago.

The recognition and determination of changes in facies of sediments occupy the attention of all stratigraphic geologists. Many such changes may be noted in the exposed rock strata, as in the Permian section of Utah and in the Cretaceous section of the Book Cliffs of Colorado and Utah. The most striking and best known example of such facies changes in this country is offered by the Permian rocks of the Delaware Basin of New Mexico and Texas. The basin was surrounded by a reef zone, and this in turn by a back reef zone. Each of these—the basin and the two zones—is characterized by different kinds of deposits. These relations are exceptionally well displayed in the Glass and Guadalupe Mountains and also by the records of thousands of oil wells in the plains east of the mountains.

Stratigraphic information and also areal geologic maps have been contributed generously by oil companies to State and Federal Geological Surveys for use in connection with official investigations in the petroleum-producing States. The publication of such modern State geologic maps as those of Oklahoma (10), Kansas (11), and Texas (3) was greatly facilitated through the active interest and support of the petroleum geologists and companies in those States. The great stock of information acquired by oil companies in California has been drawn upon in large measure in the preparation of two recently issued volumes—one entitled *Geology of California*, by R. D. Reed (14) and the other *Structural evolution of California*, by R. D. Reed and J. S. Hollister (15).

The stratigraphic information supplied by the wells drilled for oil and gas enables the geologist to draw geologic maps of the past. Such maps are areal geologic maps and they thus differ from paleogeographic maps which show the distribution of land and water. An early, and perhaps the first, areal geologic map based almost entirely on well data was one for northeastern Oklahoma compiled by Luther H. White. It was published in 1926 by the *Oil and Gas Journal* (23) and also by the Oklahoma Geological Survey (23). More recently, such maps of Kansas (8), Oklahoma (8), Texas (16), and a large portion of the United States (7) have been published. The deep drilling for oil and gas provides not alone stratigraphic information but also structural data that permit the preparation of subsurface structure maps, both local and regional in character. In the words of R. A. Daly at the banquet of the Geological Society of America in Tulsa, Okla., on December 30, 1931, the petroleum industry has contributed the third dimension to geology.

DEEP DRILLING AND SEARCH FOR PETROLEUM DISCOVER OTHER MINERAL PRODUCTS

The petroleum industry, in its addition of this new dimension to geology, has had an unusual opportunity to discover mineral products that lie deep below the surface. Commercially important deposits of five mineral products thus discovered with the advent of deep drilling and search for petroleum are natural gas, helium, natural carbon dioxide, potash in New Mexico, and sulphur in the coastal areas of Louisiana and Texas. The five industries centering around these may thus be regarded as quintuplets of mother petroleum in the household of the mineral industry. A few vital and other statistics of interest about each of the quintuplets will be mentioned.

The commercial utilization of natural gas, one of our principal sources of light and power, dates back as early as 1821 when gas from a shallow well at Fredonia, New York, was used in homes in that village. Our present marketed output of natural gas, amounting in 1937 to 2,370 million cubic feet, comes from 24 States and is transported through 85,000 miles of trunk lines to consumers in 35 States. The known reserves of this convenient and efficient source of heat and energy are, according to R. W. Richards,[2] at least of the order of 100 trillion cubic feet.

Gas wells suitable for producing solid carbon dioxide, known generally as dry ice, have been drilled in Montana, Colorado, Utah, New Mexico, and California; and plants for the manufacture of dry ice from gas supplied by such wells have been constructed in recent years at Wellington, Utah, Witt and Bueyeros, N. Mex., and Niland, Calif. Dry ice is a convenient refrigerant and is being produced in increasing quantities, due in part to the growing demand for it by transcontinental and transoceanic shippers.

Sulphur was discovered on a salt dome at Sulphur, La., in 1865 by the Louisiana Petroleum & Coal Co. while prospecting for oil. Sulphur production was begun in Louisiana in 1903. To January 1, 1938, 41,163,000 long tons of sulphur valued at over three-quarters of a billion dollars has been produced from the cap rock of salt domes on the Gulf Coast of Louisiana and Texas. Before the development of the Louisiana and Texas deposits 95 per cent of the world's supply of sulphur came from Sicily. At present these two States supply the greater part of the world's sulphur and more than 99 per cent of the domestic output.

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[2] Personal communication.

The United States possesses the only known natural gas fields in the world that yield gas sufficiently rich in helium to warrant the extraction of this element on a commercial scale. The richest helium-bearing gases, those containing 1 to 8 per cent, are found in southeastern Kansas, southeastern Colorado, eastern Utah, and in the Texas Panhandle. The production of helium on a large scale was born of the necessity to find during the World War a non-inflammable substitute for the extremely inflammable hydrogen gas in balloons and dirigibles. The operation of experimental plants in Texas and Canada, beginning in 1918, led to the erection in 1919 of a production plant at Fort Worth, Texas, and later other plants, one by the Helium Company at Dexter, Kans., in 1927, and the other by the Bureau of Mines near Amarillo, Texas, in 1928.

American potash, like our helium, was first produced during the World War and it now supplies a major portion of our domestic requirements. An energetic search for possible sources of potash in this country began in 1911. One of the possible sources thus investigated was the Permian salt of Texas and New Mexico. Information about the extent and character of the potash deposits in these States acquired from oil company wells and from Government and private core tests revealed commercial deposits of potash in New Mexico. Shipments began in 1931 and they totaled 700,000 tons of crude potash salts in 1937.

PETROLEUM RESERVES OF UNITED STATES

Our petroleum reserves, because of the nature of the occurrence of petroleum, are imperfectly known. Petroleum is a liquid contained in the rocks deep below the surface in many small widely scattered areas. It is discovered by the driller who is aided in his search by the accumulated knowledge about oil and its occurrence.

A number of estimates of the total petroleum resources of the United States were prepared between 1909 and 1921. During this period, however, it became evident that the unproved reserves in unknown fields awaiting future discovery could not be estimated with any degree of accuracy whereas the quantity of oil in the proved reserves, recoverable by then current methods of production, could be estimated with reasonable accuracy on the basis of the past production experience of depleted fields. The first estimate in which the proved reserves were separated from estimates of undiscovered fields was made in 1921 by the Geological Survey with the cooperation of the American Association of Petroleum Geologists. In this estimate

5 billion barrels were classified as oil "in sight" on January 1, 1922, and 4 billion barrels additional as "prospective and possible" and recoverable by current methods of production (18). A number of estimates have been prepared since 1921.

The individual estimates of the petroleum reserves that have been made in 1921 and subsequent years differ somewhat but they all possess a similar order of magnitude. Since 1930 the estimates of proved reserves have ranged from 10 to 15.8 billion barrels.

The proved reserves in the ground, like the stocks of petroleum held above ground, are constantly changing in quantity. They are depleted by the output of producing wells and increased by the discovery of new fields and deeper pools. During the period 1922 to 1938 for which figures of proved reserves are available many large fields were discovered so that, notwithstanding the consequent greatly augmented production, the proved reserves have increased.

FUTURE PETROLEUM SUPPLY OF UNITED STATES

The continued discovery of new fields and deeper oil-bearing zones is required to meet future demands, just as it has since the beginning of the industry in the United States. The extent to which new sources of supply are discovered and produced depends upon the payment of such prices by the consumer as will permit the industry to carry the heavy and increasing expense of new exploration and maintain profits.

Much oil remains to be discovered in new fields and in deeper pools, but the exact location of these fields and the quantity of petroleum they will yield are not known; they will not be known in advance of drilling. Nevertheless, their number, whatever it may be, is definitely limited and each newly-found field leaves one less to be discovered.

The answer to the question "When will the day of petroleum shortage in the United States be reached?" lies not alone in the supply of oil remaining in the ground. It rests also with the geologist to continue to aid in the increasingly difficult problem of discovery, with the engineer to improve drilling technique and to increase recoveries, and with the chemist to continue improvements in refining practice. In part, it rests on the price that the public can pay in the future for oil products, and that in turn depends in part on increased efficiency in use. In a large measure it rests on conservation and efficiency in the discovery, development, and production of our future oil fields.

The future undoubtedly will see continued advances in science and technology affecting the discovery, recovery, refining, and utilization of petroleum. Thus far, these advances have enabled us to keep supplies ahead of needs, but they afford us no assurance that the same record can be maintained indefinitely.

In this connection it is of interest to call attention to some of the concrete accomplishments of recent years. The recovery of gasoline from a barrel of oil has more than trebled in the last 40 years—from about 5½ gallons in 1899 to about 18½ gallons in 1937. In the 15-year period from 1922 to the end of 1936 the geologist and the petroleum engineer have aided the driller in the addition of 10.8 billion barrels to our petroleum reserves, despite the production of 12.8 billion barrels during that period. Also, from 1920 to the end of 1936 the chemist by the introduction and improvement of cracking processes, has conserved 8.5 billion barrels of crude oil (19). The petroleum engineer is meeting energetically the challenge to recover the 65 to 85 per cent of oil remaining in the ground after a field no longer yields oil by the older methods of production. Each year witnesses the improvement and extension of recovery methods, such as acid treatment and repressuring by the introduction of gas, air, and water into the oil-bearing zones. The increased adoption and refinement of such methods in areas where geologic and other conditions permit their use will lead to the recovery in places of 50 per cent or more of the total oil content of the producing zone.

Moreover, when a shortage of domestic crude petroleum arrives and there is a consequent rise in prices of petroleum products, substitutes will be drawn upon just as they are now drawn upon to some extent in some countries that are supplied with little or no oil resources. Some of these substitutes are oil products from coal and oil shale, alcohol from farm products, and gases from wood. Our future resources of coal and oil shale have been so determined by geologic evidence and exploration that we know their approximate extent and quantity. According to Dean E. Winchester (24), the oil shale deposits of the United States will yield 92,144,935,000 barrels of oil, if and when the price of oil permits. Should coal be called upon to supply the demands now met by oil and gas, the coal reserves of the United States would, according to independent estimates by T. A. Hendricks[3] and Arno C. Fieldner (5), last about 2,000 years. These two estimates are based on the assumption that the consumption of energy from mineral fuels will equal the maximum rate of consumption in the past (approximately 23,400 trillion B.t.u. in 1929) and

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[3] Personal communication.

also are based on the assumption of a 30 per cent loss of coal in mining. Concerning the cost of motor fuel substitutes, Doctor Fieldner (5) comments as follows:

> Reliable information on the cost of making gasoline from coal in British and German plants is not available, but it is believed that it is three or four times the present cost of producing gasoline from petroleum in the United States. These costs will be reduced by further research, but no other liquid motor fuel, whether it be from coal, oil shale, or vegetable matter, can hope to be as cheap as our present petroleum fuels.

The following significant statement on this subject is contained in a recent press memorandum of the Department of the Interior relative to the work of the Bureau of Mines (Oct. 24, 1938):

> By the time that depletion of our petroleum resources reaches the point when a motorized Nation must begin to look to other sources for some of its fuel, it is hoped that motor fuel can be supplied from coal so efficiently and cheaply that the transfer can be made from the old fuel to the new without drastic adjustments.

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PALEONTOLOGY.—*The crossopterygian hyomandibular and the tetrapod stapes.*[1] THEODORE H. EATON, JR., Union College, Schenectady, New York. (Communicated by C. LEWIS GAZIN.)

Romer's description, in 1937, of the braincase of *Megalichthys,* a Permo-Carboniferous crossopterygian fish, showed that the hyomandibular bone articulated with the otic region by two heads, one dorsal and one ventral to the jugular vein. This arrangement, elsewhere unknown in vertebrates, had been anticipated in part by Schmalhausen, DeBeer and Watson. They could not, however, attribute the two-headed hyomandibular to any particular fish, and their hypotheses differed greatly in details. The views of Schmalhausen and DeBeer were summarized by Goodrich (1930) in his *Studies on the structure and development of vertebrates,* and those of DeBeer again by Romer (1937). Watson's related suggestion is in his paper on the origin of Amphibia (1926).

In the summer of 1937 I had the privilege of studying the *Megalichthys* material with Dr. Romer and attempting to restore some of

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[1] Presented before the Vertebrate Section of the Paleontological Society on December 29, 1938. Received December 29, 1938.

the soft anatomy. This paper presents two suggestions: (1) That the articulations of the hyomandibular are carried over essentially unchanged, and may be identified, in the connections of the stapes with other skeletal parts in most tetrapods, and (2) that the stapedial muscle is not limited to mammals but probably came up in their ancestry from the anterior edge of the levator hyoidei of fishes. Most of the data are from published sources, but I have added to them a series of simple reconstructions and two or three new observations.

Figure 1 is a diagrammatic reconstruction of the hyomandibular of *Megalichthys* and its relations to other parts. The attachments to skeletal parts are numbered arbitrarily: 1 the dorsal process, to the parotic region of the cranium above the jugular canal, 2 the ventral or otic process, below the jugular canal, 3 the connection with the ceratohyal, 4 that with the quadrate, and 5 with the operculum. The latter two connections are not represented by distinct processes, but were undoubtedly present as close attachments in all generalized hyostylic operculate fishes. Above the groove for the jugular vein, on the posterior part of the otic region, is a smooth muscle scar, which could only be for the levator hyoidei, likewise present in generalized hyostylic fishes. Whether this muscle extended as far down as the mandible is not determined, so that its restoration is conservative. In Amphibia, however, the levator hyoidei is largely converted into the depressor mandibulae by shifting its insertion to the posterior end of the lower jaw.

Three brief comparisons with the arrangement in other fishes will show that this type of hyomandibular occupies, probably, a fairly central, primitive position in the evolutionary scheme. Figure 2 indicates the corresponding structures in a dissection of *Squalus,* a shark. The articulation with the cranium is single and ventral to the jugular vein. Probably it is equivalent to no. 2, and no. 1 is either primitively or secondarily absent. No. 5 probably never existed, as there is no evidence that sharks ever had a bony operculum.

In the advanced fishes, Actinopteri, the hyomandibular articulates with the braincase above the jugular vein instead of below, and presumably articulation 2 has been lost, on the assumption that the double-headed hyomandibular is ancestral for these fishes. Numbers 3, 4 and 5 are, of course, regularly present.

The Dipnoi, lungfishes, make a more difficult problem, as the hyomandibular is so far reduced as to be almost unrecognizable in the adult, and has lost practically all its primitive connections. But even here, in the embryo of *Neoceratodus* (Fig. 3), we may possibly see a remnant of a double cranial attachment with the jugular vein between, and also one to the quadrate and another for the ceratohyal. If this be the correct interpretation, the only one of our five connections actually missing is that for the operculum. In modern Dipnoi, at least, the operculum is greatly reduced and depends primarily upon its extensive muscle sheet for support.

Enough has been said to show that Romer's discovery may be the means of settling the long dispute over homologies of the hyomandibular and its cranial articulations in fishes. Turning back to *Megalichthys* again, the prevailing opinion for some years has been that Crossopterygii stand very close to the ancestry of tetrapods, and it should be profitable to make as detailed a comparison as possible between the hyomandibular and the amphibian stapes.

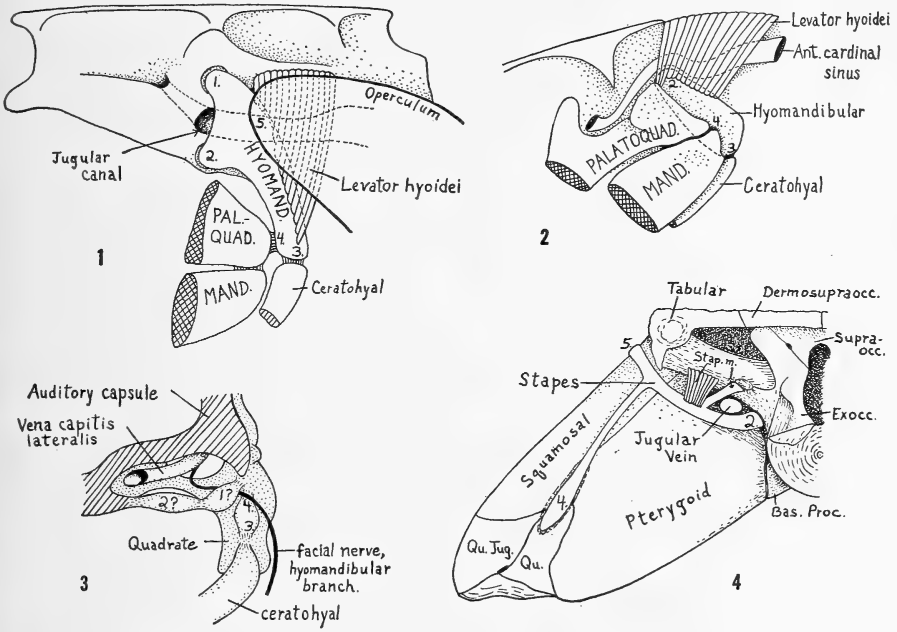
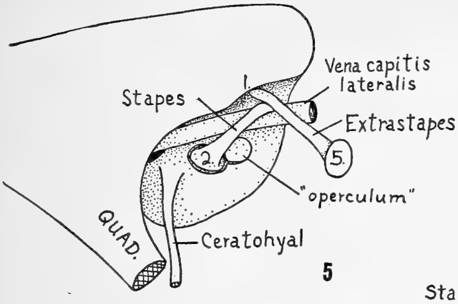


Fig. 1.—Crossopterygii: *Megalichthys*. (Adapted after Romer, 1937.) Left lateral view. Fig. 2.—Elasmobranchii: *Squalus*. Left lateral view. Fig. 3.—Dipnoi: *Neoceratodus*, embryo, 18.5 mm. (Modified after Goodrich, 1930.) Posterior view, right side. Fig. 4.—Embolomeri: *Orthosaurus*. (Based on Watson, 1926.) Posterior view, left side.

Figure 4 is a composite reconstruction of the stapes in the embolomerous Stegocephalia, based partly on Watson's figures and partly on his descriptions (1926). On the lower portion of the otic capsule the foot of the stapes rested in a pit, which, however, did not penetrate the capsule wall. He calls it the pseudofenestra ovalis. It is clearly an early stage in the evolution of a complete fenestra into the otic cavity, but presumably sound could already be transmitted by way of the stapes. Watson says he believes a dorsal process to have been present in Embolomeri, and also one to the quadrate, both of them doubtless cartilaginous. There is a small pit on the quadrate, sometimes at the point where the squamosal, pterygoid and quadrate meet (*Orthosaurus*), facing towards the otic capsule, and showing the location of the process from stapes to quadrate. Above the pseudofenestra ovalis there is a concavity along the side of the braincase which is the probable location of the jugular vein. In modern Amphibia and Reptiles this vein is above the fenestra ovalis and the foot of the stapes. It would seem, then, that the foot of the stapes, transmitting sound to the ear cavity, can be nothing but the ventral cranial articulation, no. 2, of the fish hyomandibular; that the dorsal process to the parotic region of the cranium is no. 1; that the quadrate connection, no. 4, is present as a cartilage rod in some cases. No doubt during ontogeny the hyoid attachment, no. 3, is temporarily present; whether it continued through life in a ligamentous form is, of course, impossible to say. But we still have one end unaccounted for. In Stegocephalia this end extended outwards in the otic notch to the level of the skin, that is, to the ear drum. Connection no. 5, to the operculum in Crossopterygii, was located on the outer face of the hyomandibular, therefore certainly nearest to the skin, as the operculum was a superficial, dermal bone. When the operculum disappeared, with the transition to land life, this part of the hyomandibular might most readily have been left attached to the integument and have served to receive sound vibrations from outside, while that area of the integument became the ear drum. Watson remarks that the bony stapes of Embolomeri seems to lie at right angles to that of, for instance, *Osteolepis*, the Crossopterygian which he used for comparison. We can see that this is not so much a shifting of position of the bone as the development of a new axis, namely from the fenestra ovalis to the otic notch instead of from the parotic process to the ceratohyal.

The bulk of the levator hyoidei muscle of Crossopterygii had, with the reduction of the hyomandibular, changed its insertion to the mandible, being known from now on as the depressor mandibulae. But there can be little question, on the basis of evidence from certain reptiles and from mammals, that in early Stegocephalia a slip of this muscle continued to insert on the stapes, its origin being somewhere close to the parotic process and its course being external to the jugu-



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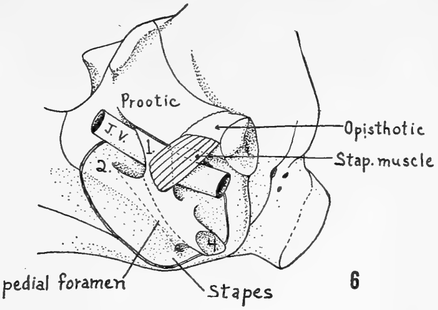

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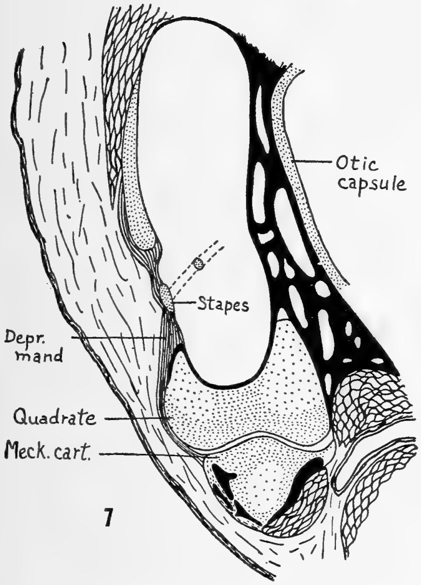

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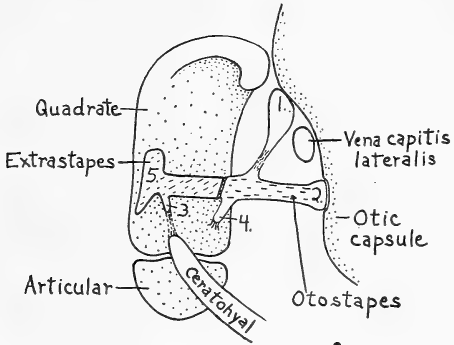

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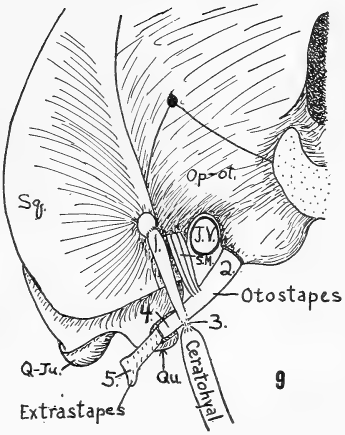

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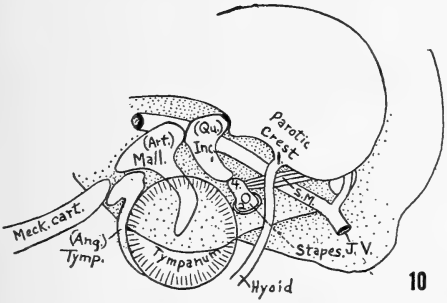

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Fig. 5.—Anura: *Rana catesbeiana.* Left lateral view. Fig 6.—Cotylosauria: *Captorhinus.* (Adapted after Price, 1935.) Left lateral view. Fig. 7.—Chelonia: *Chrysemys marginata.* (Just hatched, C. L. 25 mm.) Left otic capsule, transverse section. Fig. 8.—Lacertilia. Generalized diagram. Posterior view, left side. Fig. 9.—Theriodonta: *Kannemeyeria.* (Adapted from Pearson, 1924.) Posterior view left side. Fig. 10.—Marsupial embryo. Generalized diagram. Left lateral view.

lar vein. This is the ancestral stapedial muscle, which does not seem to be limited strictly to mammals, and which receives a branch of the facial nerve, as it should according to this scheme.

Among modern Amphibia the stapes of the adult contributes little to knowledge of the auditory region of any other types. In Caecilia and Urodela it is much reduced and even the ear drum itself is secondarily lost, while in some Urodela a substitute apparatus develops to transmit sound to the ear by way of the shoulder girdle. In Anura, however, something more like the primitive condition exists (Fig. 5). The bony stapes fits into the fenestra ovalis beneath the jugular vein. Laterally, reaching to the ear drum, is a cartilaginous extrastapes, which may be considered a modification of the distal end of the stapes itself. This, near the point where the bony part begins, connects with the parotic crest dorsal to the tympanic cavity and jugular vein (no. 1). Temporarily, during development, strands of procartilage reach to the quadrate and the ceratohyal, but the latter presently fuses to the cranium, as shown. There is no stapedial muscle in the modern Amphibia, and their auditory structure is definitely off the line which led to higher forms. But we can see that the five points of attachment already described persist in the Anura, three of them in the adult.

One of the oldest reptiles on which any information about the stapes has been obtained is the Cotylosaur *Captorhinus* (Fig. 6). The braincase was described and carefully figured by Price (1935). The stapes, a relatively large one, was perforated by a canal for the stapedial artery. The expanded foot (no. 2) fitted the fenestra ovalis beneath the jugular canal, and a slender dorsal process (no. 1) articulated with the prootic. Judging from other Cotylosaur material (e.g., *Labidosaurus*, Williston, 1910), the distal end of the stapes reached the corner of the quadrate at the junction of the latter with the pterygoid, or connected with it by a cartilage process. Evidently there was a cartilaginous extrastapes, for otherwise the stapes, as shown, could not have served for sound transmission. On the anterior face of the dorsal process (no. 1) Price found in *Captorhinus* "indications of a strong ligamentous or muscular attachment." Whether ligamentous or muscular, this structure was probably the stapedial muscle or its vestige, and I have shown its possible position in this figure.

An interesting bit of evidence on the stapedial muscle occurs in embryo turtles, for example in *Chelydra* and in *Chrysemys* (Fig. 7). A section made through the tympanic region of the latter at the time of hatching shows the anterior edge of the depressor mandibulae muscle attached directly to the end of the extrastapes, but at the same time continuing down to the lower jaw. This connection, which I would interpret as a passing remnant of the attachment of a separate muscle to the stapes, disappears shortly, but is represented in adult turtles by a short ligamentous connection of the depressor muscle to the cartilage rim of the ear drum cavity.

The condition in some lizards closely resembles our reconstructed Stegocephalian and Cotylosaur ear, and all five of the primitive attachments of the stapes occur during ontogeny (Fig. 8). No. 1, the dorsal process, develops in temporary connection with the body of the stapes, lies externally to the jugular vein, and finally separates as an "intercalary" cartilage. An opposite process (no. 4) goes to the quadrate and usually persists through life. Temporarily the stapes is connected with the ceratohyal (no. 3). No. 2 and no. 5 are present as the functional inner and outer ends of the stapes, just as in Embolomeri, but no. 5 is cartilaginous (an extrastapes).

Before considering the somewhat more difficult problem of the mammalian ear it is necessary to try restoring the complete stapes of a Theriodont, if possible, from the work of Broom, Watson and others. Since very few of the known mammal-like reptiles have much of the auditory apparatus remaining in the fossils, we must select one which happens to show it most clearly, without regard for the particular line which may lead to mammals.

A diagram of an occipital view of the ear region in the Anomodont *Kannemeyeria* (based on Pearson, 1924) will suggest two or three important changes which took place as the mammalian ear evolved (Fig. 9). The stapes was a short, bony rod reaching from the fenestra ovalis to the inner edge of the quadrate, where its distal end rested in a groove. There was undoubtedly, as in other reptiles, a cartilaginous extrastapes, although it need not have been long, for the ear drum may have been slightly sunken into a canal already. The quadrate itself was in the process of reduction and formed only the inner portion of the jaw articulating surface. The fenestra ovalis, and therefore the foot of the stapes, was ventral to a deep notch in which it is safe to say the jugular vein passed. The whole auditory apparatus had come farther ventrad and mediad than in amphibians or other reptiles. There is a distinct parotic process on the border between the squamosal and opisthotic. Lateral to this, on the squamosal, was a broad trough providing an origin for the depressor mandibulae. Considering that the parotic process in earlier types receives articulation no. 1 (the dorsal process) from the stapes, and that it is external to the jugular notch, I think that we may look for a homologous structure to attach to the same place in some of the mammal-like reptiles, that is, a dorsal process from the stapes or its equivalent. We may also suspect that the stapedial muscle originated on the face of the opisthotic just inward from the parotic process.

If the interpretation is correct so far it should not be too great a jump to the stapes of a primitive mammal in an embryonic stage (Fig. 10). The dorsal end of the hyoid arch becomes attached very early to the parotic crest dorso-laterally from the stapes proper, and externally to the jugular vein. This end of the hyoid is then called laterohyal or stylohyal. Goodrich (1930) noted its similarity to the dorsal process of reptiles. I suggest that this dorsal process of the reptilian stapes has detached itself, during the early evolution of mammals, from the remaining portion of the stapes, and associated with the hyoid alone (connection no. 3). It is possible, then, that in *Kannemeyeria* and its relatives the dorsal process was already becoming a so-called "stylohyal" and supported the ceratohyal directly, while the inner part of the stapes, with its extrastapedial, was more completely freed for auditory transmission. The stapes of mammals has lost the extrastapedial because the quadrate and articular moved into the ear cavity and took its place. The stapedial muscle, becoming almost microscopically small, is still associated in mammals with the auditory stapes proper.

The associations of parts, then, in the mammalian ear, are new, but the old morphological features of reptiles, amphibians and even fishes are still there and may be recognized, according to this theory. It may be that with the evolution of a mammalian larynx, and mobile muscular tongue, along with chewing movements of the lower jaw, there was reason for a more sturdy attachment of the hyoid arch to the cranium, and the most convenient method of obtaining it was by annexing the dorsal process of the stapes. At the same time the remainder of the stapes came to depend on the quadrate, while the latter was still in the upper jaw, for a more complete support than it had in amphibians or most reptiles, and thus drew closer the original attachment no. 4. At some time, as Broom pointed out (1912), there must have been a double articulation between the mandible and the upper jaw, consisting not only of the old joint between the quadrate and articular but of a new one between squamosal and dentary. In time the latter survived, while the quadrate and articular, being very close against the ear drum, were drawn into the auditory complex and replaced the old cartilaginous extrastapes.

Summary.—The crossopterygian hyomandibular bone, evolving into the tetrapod stapes, retains its original morphological relations largely unchanged, even to mammals. New functions and new locations of parts appear, but the connections, I suggest, remain essentially as follows: 1. The dorsal cranial head of the hyomandibular becomes the dorsal process of the stapes, and, in mammals, the so-called stylohyal. 2. The ventral head of the hyomandibular, below the jugular vein, becomes the foot of the stapes and occupies the fenestra ovalis. 3. The connection of the hyomandibular with the ceratohyal generally does not persist beyond early developmental stages in tetrapods, but apparently in the line leading to mammals the ceratohyal was still able to link itself to the cranium through the dorsal process of the stapes. 4. In many types the attachment to the quadrate disappears except in early development, but it was shown to be present in early Stegocephalians, Cotylosaurs, lizards and the mammal-like reptiles, while in mammals it becomes the joint between the stapes and the incus. 5. The attachment of the hyomandibular to the operculum in fishes seems to furnish a convenient point for that between the stapes and ear drum in early tetrapods. Later this end of the stapes became cartilaginous and was finally atrophied in the transition from reptiles to mammals.

The levator hyoidei muscle became split, in Amphibia, into a large depressor mandibulae and a small stapedial muscle, the latter probably being limited to certain Stegocephalia. Traces of the stapedial appear in some primitive reptiles, and in mammals it is regularly present, while the depressor mandibulae serves the Amphibia, reptiles and birds, but in mammals is replaced by the digastric.

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EVOLUTION.—*The course of evolution.*[1] ROBERT F. GRIGGS, George Washington University.

To evince an interest in orthogenesis or even to recognize that it is entitled to serious consideration by a scientific society is perhaps a somewhat dangerous admission. For many biologists consider orthogenesis a relic of the mystical childhood of evolutionary doctrine quite of a piece with the transmission of acquired characters and scarcely to be mentioned in a respectable Society. One authority expresses the feeling of many when he bluntly calls orthogenesis an "anachronism." Altenburg holds that "The theory of orthogenesis depends for its acceptance not so much on our knowledge of certain facts as it does on our ignorance of them."[2]

Yet the officers of the Paleontological Society ask me to open a discussion of the subject; because, in the words of their invitation, "The consideration of orthogenesis by the Society several years ago did not clarify the subject."

This statement again is an admission, at least that the subject is difficult to clarify. What chance is there of reaching a clearer understanding this time than on the previous occasion?

IS ORTHOGENESIS ESSENTIALLY MYSTICAL?

The zoologists' objections to orthogenesis so cogently set forth during the earlier discussion by Dr. Friedmann boil down, I believe, to the supposition that orthogenesis is essentially a mystical interpretation of evolution which calls into play not only unknown but unknowable agencies which are beyond the reach of scientific inquiry, that orthogenesis is really a Doctrine of Faith rather than a Law of Science. In so far as this is correct, the subject is certainly out of reach of scientific discussion; and if this be the whole truth, we can no more hope to reach a decision on orthogenesis than we could on one of the questions debated by the old Scholastics.

But if orthogenesis were, wholly outside the realm of evidence, it would in these modern days no longer constitute any problem at all. Its difficulty lies exactly in the fact that both natural and supernatural considerations have entered into its discussion. The problem is then to disentangle these elements. Needless to say, I shall not attempt to consider the mystical elements—not because I disbelieve in a theistic universe but because as I have said, that is a matter for

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[1] Presented before the Paleontological Society of Washington at a symposium on orthogenesis, November 16, 1938. Received December 14, 1938.

[2] ALTENBURG, EDGAR. *How we inherit.* P. 120. 1928.

faith and is not susceptible of proof or disproof by scientific methods.

As in any controverted subject, we may well begin with a definition. Is it correct to state that the essential feature of orthogenesis is that it holds that evolution proceeds in definite directions rather than at random—that the course of evolution follows definite trends? And further it is usually held, I believe, that the tendency to fall into such definitie lines of evolution is characteristic of the nature of protoplasm itself. Other elements which have entered into the conception are, I think, mostly concerned with external causes of the trends and are, in the absence of any real understanding of such causes, mystical, or, to say the least, highly speculative.

Observers are not wanting, however, who strike at the very idea of evolutionary trends quite apart from any considerations as to cause. Altenburg says flatly that orthogenesis "contradicts all that we know about mutations, especially as shown by the careful studies made on the insect *Drosophila,*" and again, "The mutation theory also makes untenable the theory of orthogenesis, according to which changes take place along predetermined lines and not in all directions as demanded by the mutation theory."

Here we have clearly set down the divergence in philosophy that has arrayed biologists in two hostile camps, the one dominated by the zoologists and the other by the paleontologists.

Is evolution haphazard, produced by mutations which occur in a miraculous manner, essentially supernatural in that they are caused by circumstances entirely outside of the ordinary run of nature? In this view, the only means by which the orderly relationships which we observe throughout nature could be produced is by natural selection. The adherents of such a theory account for the steady progress of the Equidae from a primitive five-toed ancestry down to the single-hoofed horses of today by the natural selection of random mutations alone. This theory would seem to me to put its adherents under a serious disadvantage at the start by imposing on them the necessity of proving that at every step in the evolution of the horse each slight decrease in the size of the lateral toes was an advantage great enough to favor in the struggle for existence those individuals which possessed it over those which did not.

Not all the geneticists, even though they have no use for orthogenesis, adopt this extreme view. Newman[3] states a very much stronger and I believe more generally held position when he writes, "It should be said that definitely directed evolution is now believed

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[3] NEWMAN, H. N. *Readings in Evolution.* 3rd ed., p. 36.

to be one of the laws of organic evolution but we have no clear ideas as yet as to what are its underlying causes. Therefore *orthogenesis is not a causo-mechanical theory of evolution at all.*" (Italics in original.) Having thus delivered themselves, the geneticists smugly withdraw to their milk bottles to nurse their *Drosophila* and the paleontologists may throw as many of their figured stones at them as they please without in the least disturbing their self-satisfied self-sufficiency.

If the attitude of the unorthogenetic brethren were entirely snobbery, it would not last long and we would not need to concern ourselves with it. The truth is, however, that they have opened up a serious weakness in the orthogenetic position. In the minds of many men, the theory of orthogenesis shares with the so-called theory of special creation the onus of being merely a pseudo-explanation of the facts with which it deals. They hold that it substitutes a name for an explanation and really carries its adherents not one step closer to an understanding of the facts. Worse than that, they feel that instead of clarifying and stimulating thought, it puts it to sleep.

In so far as this has been true, orthogenesis deserves all the contempt with which it is held in some quarters. Certainly the paleontologists want to be very careful to purge themselves of every vestige of this sort of loose thinking before they take up the cudgels in its defence.

But on the other side, are the geneticists, having admitted the reality of orthogenesis, justified in dismissing it from further consideration because we do not understand its causes? If this is a proper attitude we should also drop all consideration of evolution itself for assuredly we know very little about its causes either.

If we agree that we have no comprehension of the causal factors at work there yet remains the very large task of mapping the evolutionary trends which are observed. And since some disbelieve in the very existence of orthogenetic trends, it may be advisable to reassemble the evidence which appears so convincing to the adherents of the theory. Yet it would seem that the old masters like Cope have done that well enough and that it would be better to refer to the literature. In any case, I shall not undertake this task but will concern myself merely with another side of the question. True or not, is the study of orthogenesis worth while?

It is an axiom that the value of a scientific theory depends not so much on its truth as upon its usefulness. The reason lies of course partly in the difficulty of ascertaining absolute truth and partly in that our problem is to master our environment. The question really before us is then, I believe, not is orthogenesis true but is it of any good to us? Can we make orthogenesis bring forth useful results?

It is to that question then that after this preliminary clearing of the ground I would address myself.

Very definitely I believe that due consideration of the conclusions which orthogenesis demands would greatly strengthen taxonomy if indeed it did not give us a whole new outlook upon the plant and animal kingdoms. For I believe it can be demonstrated not only that evolution proceeded orthogenetically but that the orthogenetic lines in many groups of organisms, both animals and plants, have pursued similar trends, in other words that evolution runs a definite course and that the course has followed the same paths in entirely unrelated phyla.

For that reason I have entitled my discussion *The course of evolution.*

I. AGGREGATION AND MULTIPLICATION

The first stage in evolution, after the living units themselves have been produced, is aggregation or multiplication. This occurs at many levels all along the line from the lowest to the highest. (1) Dividing cells, failing to separate, form colonies and multicellular animals. (2) In the fern-allies, the sporophylls become aggregated into cones which are the starting point for all the complex evolution of the flower. (3) In the lower invertebrates, segmentation into a series of similar somites, as in the annelid, lays the foundation for most of the evolution of the animal body.

(4) In corals and jellyfishes, where asexual reproduction by budding plays a large role, the daughters often fail to separate and make possible complex polyzoid individuals closely resembling the colonial vorticellas except that the bells are multicellular individuals instead of single cells.

(5) The single meristems of lower ferns and cycads multiply in higher types until a freely branching plant body is produced. Exactly similar branching bodies with many terminal branches are produced in a number of unrelated groups of sedentary animals such as ascidians, sponges, bryozoans, and in at least one crustacean, *Thompsonia.*

(6) In the highest flowering plants the flowers, originally solitary, become aggregated into clusters with reduction of the subtending leaves to bracts and the clusters take on an individuality of their own, and become the well-known composite heads of the aster family.

Here special leaves simulate sepals, special flowers, petals, etc. This achieved, the composite clusters start out on an independent evolution of their own, repeating many of the steps earlier taken in the evolution of the solitary flower.

(7) Again in the grass family, we find the individual flowers, reduced to their lowest terms, associated first in loose panicles, then brought close together until, in all but the very lowest bamboos, the aggregate becomes a new unit, the spikelet, which again goes through a complete cycle of evolution on its own level. (8) Then clusters of spikelets go through another parallel cycle of evolution on a higher level, until finally such a complex unit as the ear of maize appears on a still higher level.

In short, wherever you find organisms or organs tied together in permanent association, you may expect to find the development of a new unity and the beginning of a new cycle of evolution.

(9) Even where the units are not stationary, something of the same nature occurs as, for example, in the social insects where assuredly the organic unit is the colony like the hive of bees and not an individual such as the worker. The queen bee has become essentially only an organ of the colony—its ovary. True, she retains her eyes, legs, wings, and other organs but so, in the multicellular body, does every cell retain the fundamental structures and functions of the original free-living protozoon.

I need hardly add in these troublous times that most of the problems of human society spring from the fact that we have not yet learned how to associate in larger units and that, if we do not exterminate ourselves in the process, evolution will surely carry us into some form of collective unity. Already this industrial age has made impossible any such individual independence as that of our pioneer grandfathers who settled this continent in isolated self-sufficient groups.

In studying the evolution of any one of these aggregates, we see that in some way living units in close proximity inevitably influence each other's development, and here we approach an understanding of the cause of orthogenesis. We may return to seek explanatinos later, but now we must go on with the process itself.

As has appeared from the mere catalog of various types of aggregates, aggregation is the foundation on which later evolutionary processes are built. Once the aggregate—colony, tree, flower cluster, or society—has been established, evolution follows a rather definite course.

II. REDUCTION

A. *Reduction in number of similar parts*

The next stage after the preliminary aggregation has been completed is a reduction in the number of similar parts.

Flower parts.—The lowest flowers, both monocot and dicot, like magnolias, buttercups, sagittarias, anonas, potentillas, and water-lilies, have large numbers of flower parts: 50–100 sepals, petals, stamens, and/or carpels as the case may be. That these are really the most primitive of the flowering plants is evidenced by the fact that in these types, and in no others, monocots and dicots come close together. The flowers of the dicot buttercup and the monocot *sagittaria* are practically indistinguishable. All of the higher types have the parts reduced to smaller numbers: 6-5-4-3. In many cases there are vestiges of the larger numbers formerly present.

There is, further, good evidence that various types of both dicots and monocots have radiated from a common type similar to the polymerous buttercups and *Sagittarias.*

Gill arches.—A similar reduction in the number of gill arches occurs in the lowest chordates. *Amphioxus* has 100 or more. In the cyclostomes, *Bdellostoma* has 15 to 10, other cyclostomes 9 or 8. In the elasmobranch sharks, *Heptanchus* has 9, *Chamaeselachus* 8, but the usual number is 7; while in ordinary fishes it is reduced from 6 in the embryo to 4 in the adult, but some fishes have lost one or two of these, leaving 3 or 2.

Segments.—In a general way, the phylogenetic order of several classes of invertebrates corresponds with the number of their somites. Annelids have more segments than millepedes and, of course, are far more primitive. Millepedes have more than centipedes; centipedes more than scorpions; scorpions more than insects.

Among crustaceans, branchiopods like *Apus,* with forty to sixty-three pairs of trunk limbs, are nearer the aboriginal type than *Malacostraca* like the crayfish with fourteen trunk appendages, and they in turn are more primitive than hermit crabs and true crabs which have lost or nearly lost their abdominal appendages.

Vertebrae.—The lamprey may have 400 vertebrae. Among the elasmobranchs, *Alopias* may have more than 200 in the tail alone, *Raja* about 150, while *Heptanchus* has only a few more than 100. The cod has 52, man 33.

Teeth.—The sharks have several hundred teeth. Teeth are still very numerous in the teleosts and may be present on all the bones of the mouth. In the Amphibia, there is in general a considerable diminution in the number of teeth as compared with the fishes, but they still occur regularly on vomer and palatine in addition to maxilla and premaxilla and sometimes develop on the parasphenoid as well.

In reptiles the teeth are still numerous and widely distributed on several oral bones.

Up to the mammals, there is generally an indefinite succession of teeth throughout life, so that any loss is promptly replaced. The European viper, for instance, has as many as nine poison fangs in reserve which come into play successively as their predecessors may be torn out.

In the mammals, succession is reduced to the familiar two sets of teeth, and there is a plain tendency both further to reduce the number and do away with the division into two sets. The opossum has fifty teeth, but the ideal placental would have only forty-eight, and on account of losses here or there none exceeds forty-four except some of the whales whose teeth constitute a special problem. To be more specific, the dental formula of the dog is $\frac{3\text{-}1\text{-}4\text{-}2}{3\text{-}1\text{-}4\text{-}3}=42$, but in the cat the teeth are reduced to $\frac{3\text{-}1\text{-}3\text{-}1}{3\text{-}1\text{-}2\text{-}1}=30$. The lynx is made a separate genus because it has lost the first premolar of the upper jaw, and brought the dentition down to $\frac{3\text{-}1\text{-}2\text{-}1}{3\text{-}1\text{-}2\text{-}1}=28$.

The losses of specific teeth among the mammals, however, are obviously of a different character from the general reduction in number met in the lower classes and bring us to the consideration of the next type of orthogenetic trend.

Before going on, however, a caution should be noted.

Nobody should suppose that in any of these cases, we are attempting to cite actual lines of descent. The evidence indicates, rather, and I think most students would agree, that the actual ancestors of the higher forms listed passed through stages where the organs in question (not necessarily the whole organisms) corresponded with the earlier stages given.

Nor could it be maintained that recognition of the sequence in such cases as have been given could be of much use to taxonomy. In most of these cases everybody recognizes the more primitive types from other criteria. Useful applications of this and the other principles to be given are to be had in working out the status of smaller groups which are made up of species much more closely related. For illustrations of this sort, I must turn back to the plants which I know better.

Take the tribe of grasses known as Festuceae. In *Eragrostis major*, there are 40 to 10 similar flowers; in *Eragrostis minor*, 20 to 8; in the related blue grass, *Poa pratensis*, 5 to 3. In *Cynosurus*, the fertile spikelets are 3- to 2-flowered. *Lamarckia* has numerous vestigial flowers in the sterile spikelet, and in the fertile, one perfect flower with vestiges of a second.

In the Chlorideae, *Leptochloa* has 12 to 3 flowers; Eleusine 7 to 3; *Gymnopogon* rarely 3 or 2 but normally only 1; *Bouteloa* several flowers, all but one vestigial; and *Cynodon* is constantly one-flowered.

In the Hordeae, *Agropyron Smithii* has 13 to 7 flowers; *Agropyron repens* about 5, *Agropyron pauciflorum* 2, barley and all the highest most specialized genera are reduced to one flower.

In the higher tribes of grasses, the spikelets are uniformly one-flowered, but vestiges of a second flower are usually present. These are, however, in different relations to the fertile flower, thus indicating independent but parallel reduction from different ancestors.

B. *Fixation in the number of parts*

The third of the orthogenetic trends I shall mention is inextricably associated with the preceding. Not only are the numbers of parts reduced but the number is fixed. In the earliest stages, the numbers are large and indefinite. They become smaller and definite.

Not only do mammals have less teeth than the lower groups, but the number of teeth is nearly always constant, and even varies comparatively little even in the large groups. Not only are the petals of ordinary flowers reduced to 6-5-4 or 3; they are, with only minor aberrations, fixed at 6 or 5 or 4 or 3, and as all of you know, these numbers are characteristic of whole families or even orders.

The same trend occurs in the higher level of the flower cluster of the aster family. In most composites, the number of disc flowers, ray flowers, and bracts is large and indefinite; but here and there the head has been reduced to a definite organization. Thus, in Cosmos and related genera, there are 16 bracts in the involucre in two sets of 8 each and 8 ray flowers, each set alternating in position with the one outside it. In our common *Chrysogonum*, the involucre is made up of 10 bracts in two sets of 5 each, the inner of which wrap around the ovaries of the 5 fertile flowers. Other flowers are present but vestigial.

So on down the list in each of the illustrations cited above and throughout nature generally, the numbers of parts become fixed and standardized at a relatively early stage in evolution; and thereafter the reductions which occur are, like the loss of the vestigial premolars in the lynx, very minor compared with the wholesale reduction that occurs earlier.

C. *Consolidation*

At a third stage in the reduction process, other tendencies begin to creep in which later become manifest in the development of new units. Primitive types are loosely knit. During the course of evolution they become more and more compact.

In plants, consolidation expresses itself especially in the organization of flowers and flower clusters. Primitive flowers were solitary. Next they began to aggregate into loose clusters, the stems of these shortened produce simple *racemes;* further shortening of branches gives rise to unbranched *spikes;* the main axis then shortened, drawing all the flowers down into a compact *head.*

Similarly the axis of the individual flower is shortened from the primitive condition of a pine cone seen in *Magnolia* to the stage of most flowers where the parts, instead of spiralling up an elongated axis as in the cone, are in circles one above another.

Although this completely-eliminated axis might seem to represent the theoretical limit, stoppage of axial elongation goes much further in many families where the axial growth is inhibited before lateral growth is complete, with the result that the lower parts pile up around the center and the flower turns itself inside out, so to speak. Thus, an epigynous flower is produced in which the parts originally basal—sepals, petals, and stamens—are carried up around the ovary. In some cases, as in four-o'clocks, roses, and lythrums, the tube grown up around the ovary remains free from it but in a large majority of such flowers, the elevated parts grow fast to the ovary as in apples, melons, blueberries, and gooseberries.

This orthogenetic trend is so characteristic and prevalent that it appears independently in many unrelated orders. To those mentioned we might add honeysuckles, composites, lobelias, cacti, begonias, aralias, carrots, and hydrangeas.

The mouth parts of arthropods, originally the segmental appendages of the somites in the oral region are in all but the lowest forms brought into close contact and fitted together around the mouth. As in the flower clusters there is remarkably little tendency toward fusion of the separate appendages.

Our own skull is as notable an example of this sort of thing as any. The skull of primitive vertebrates consisted of a loose basket-like aggregation of separate bones in which the mandibular, the auditory, the ocular, and even the olfactory regions were distinct units hung around the cranium but by no means a part of it. Here again although complete unity has been achieved by closely interlocking sutures, there is remarkably little fusion of bones.

The same tendency toward consolidation of loosely arranged structures is manifest in the nervous system of arthropods. The primitive groups have a double chain of ganglia strung along the length of the body. But the commissures between these have shortened up in all higher forms. Here, as in the development of inferior ovaries in flowers, the consolidation of the parts carries us much further, into another type of reduction which is the next step.

D. *Coalescence of free parts*

The fusion of parts originally separate is carried out even more conspicuously in flowers by horizontal fusions than by the vertical concrescence around the ovary described in the development of flowers with inferior ovaries.

The recognized distinction between lower and higher dicots is in the fusion of the separate petals, such as we find in pansies, into united corollas, as in petunias. Traces of the originally separate petals remain as ribs of the united corolla as in morning-glories or as projecting lobes as in phloxes. While all of the highest dicots thus have sympetalous corollas, there is abundant evidence that fusion really occurred and/or perhaps is still occurring over and over again independently in scores of families, as for instance in the Leguminosae where the flowers are certainly polypetalous but show varying degrees of fusion in many different genera. In the heath family, Labrador tea has separate petals but in most of the genera they are fused as in Azalia and Mountain laurel. In the olive family, the petals of fringe-tree and forsythia have barely united at the base, but those of lilac are joined half-way up.

All the other flower parts show the same tendency, and there is every evidence that fusion has occurred independently in many unrelated families. Thus we have united sepals in the calyx of a carnation, united carpels in innumerable fruits like orange, apple, banana. melons, etc. etc.

The trend toward fusion frequently reappears in clusters of flowers. Thus, a mulberry (*Morus*) resembles a blackberry, but while the blackberry is produced by the partial coalescence of the carpels of one flower, the mulberry is due to the fusion of many flowers, each one of which becomes a lobe of the fruit; and this tendency, manifested in various ways, is characteristic of the whole family Moraceae, e.g., bread-fruit and fig.

A pineapple is a similar aggregate. The fruit which we eat includes the bracts as well as the ovaries of the many flowers as can be readily demonstrated by inspection of the fruit or more clearly yet, of the numerous showy blossoms at flowering time.

Fusion of parts originally free is equally marked in animal organs. Everyone who eats chicken notes that the backbone in which the vertebrae, which may still be readily counted, is united into two units, one supporting the wings and the other the legs. That this consolidation has developed in the class Aves is shown by a glance at *Archaeopteryx* where there is little more fusion of vertebrae than in reptiles.

The segments of the originally simple arthropod body have been consolidated, as everybody knows, into the most highly differentiated cephalothoracic regions of insects, crustaceans, and spiders until decision as to the exact number of segments of the aboriginal ancestor has become as difficult as in the vertebrate skull.

The brain of arthropods and apparently that of vertebrates also originated in similar fashion.

E. *Elimination of some organs*

After large and indefinite series of organs have been reduced to small and definite numbers, the next step in the reduction process is the complete elimination of some sets.

Among flowers, the loss of petals or sepals or stamens or carpels is exceedingly common. Very often elimination has not been quite complete and tell-tale vestiges of the lost organs remain.

Elimination of floral organs has occurred, so to speak, both wholesale and retail. There are whole regions of the Angiosperms where the flowers have been reduced almost to their lowest terms such as the grasses, sedges, willows, hickories, oaks, birches, and spurges. Many individual genera or even single species in families with complete flowers have also suffered similar losses, as for example *Isnardia* in Onagraceae, *Aruncus* in Rosaceae, some species of ash in Oleaceae.

Great confusion has resulted among botanists from failure to understand that these flowers are reductions. It used to be supposed that such rudimentary flowers as willows and poplars were primitive and that evolution had proceeded by the addition and division of parts until finally the complete polymerous flowers of buttercups were achieved. There is no occasion here to go into the merits of this old controversy. Suffice it to say that if the terminal reduced twigs of the phylogenetic tree are regarded as relics of former main trunks, it is as difficult to find the connections with the roots as it would be if a similar attempt were made with an oak tree. Worse yet, each separate twig would require a different root and the family tree would become polyphyletic with a vengeance!

One of the most fundamental eliminations of organs is in the sex organs of the vertebrate. The male and female sexes start development alike, clearly pointing back to a primitive hermaphroditic condition. The embryo lays down two urinogenital outlets on each side, the Wolffian and the Muellerian ducts. In the male, the Wolffian duct becomes the seminal duct and the Muellerian atrophies. In the female, the Muellerian duct becomes the Fallopian tube and the Wolffian atrophies.

Eliminations in animals are so numerous and generally recognized that there is hardly need to point them out. Snakes have lost all their limbs, and some boas retain vestiges to prove it. Whales and sea cows have lost their hind limbs. *Dinornis* has only the slightest vestiges to show that it ever had wings, and other flightless birds like cassowaries, apteryx, and the ostriches show various stages in the loss of their wings.

III. DIFFERENTIATION

A. *Differentiation of parts originally similar*

Soon after the number of parts is fixed, differentiation sets in. Parts originally similar become specialized to subserve diverse functions. Similar spike teeth segregate into incisors, canines, and molars. The vertebrae, all alike in the fishes, diversify until each one takes on peculiarities of its own.

In flowers, the regular radiate blossom with petals all alike becomes a very irregular lipped flower like an orchid, a pea, or a snapdragon. All stages of the process may be seen in many unrelated families. The lowest member of the figwort family is the familiar mullein with almost regular flowers still retaining the primitive 5 stamens. From this there is a complete series to the most irregular flowers like snapdragons and louseworts in which the stamens are reduced to 4 or 2 and twisted out of all semblance to the straight and regular organs of the ancestral flower.

In the Leguminosae, all transitions from regular flowers like *Mimosa* through *Cassia* down to the highly one-sided peas are familiar.

No such series occurs in the orchids, all members of the family having very highly one-sided flowers, but botanists place orchids at the summit of the monocots for exactly this reason. That is, though the stages in their differentiation are gone, we recognize the applicability of the rule in assigning them this position.

B. *Progressive sterilization*

The original and most fundamental differentiation was the sterilization of most of the cells in the body. In the original unicellular organisms all cells were of course reproductive. The most primitive colonies are in the same condition. But very early reproductive functions were restricted to special cells. From that time on, a large part of the course of evolution has centered around a continuously progressive sterilization of reproductive tissues with accompanying differentiation of the sterilized elements into vegetative organs.

This is hardly the place to call attention to the fact that the so-called "race suicide" of the cultured classes, which bothers us so much, is a homologous biological phenomenon. How serious it may become we cannot guess, but we may remark that there was probably no occasion to worry over the "suicide" of the first brain cells.

But this aspect of progressive sterilization, followed by differentiation, brings us to another well-known characteristic of living organisms.

IV. SUBSTITUTION OF ONE FUNCTION FOR ANOTHER

All of you are familiar with the fact that almost every new organ of animals and plants consists of an old one made over to serve a new function.

Stamens and carpels are clearly "made-over" leaves. This is not manifest from inspection but is clearly demonstrable by study of comparative anatomy.

Similarly, petals and sepals are as definitely sterilized stamens made over into new functions. While the original differentiation of sepals and petals occurred in the unknown ancestry of the Angiosperms, the orthogenetic tendency in that direction continues in many families.

The flower of canna has its full complement of both sepals and petals, but those are not what you see when you look at a canna flower. The conspicuous part of this flower consists of sterilized stamens enlarged and made petaloid. Only one-half of one stamen remains functional, riding like an appendage apparently out of place on the big staminode to which the rest of it has been transformed.

The tendency to make stamens over into petaloid structures is pronounced throughout the higher monocot families, viz., in bananas, gingers, arrowroots, and orchids as well as in cannas.

But the same tendency is latent in many families of flowering plants, dicots as well as monocots, even though it does not normally come to expression. Many of the "double" varieties, which occur in almost all types of ornamental plants, are produced simply by the conversion of stamens into petals, as you may see by comparing wild roses with our hybrid tea types.

The metamorphoses of fins of fish to legs, of the forelegs to flippers in whale, to wings in bats and birds, are too familiar to be mentioned. The scales on the top of the fish's head became part of the bony skull.

It is so obvious that there is no need of saying it that a species with metamorphosed structure has been derived from one unchanged. The point for us here is that such metamorphoses take a long time, that there are many stages in the process which therefore constitutes an orthogenetic trend.

V. ANNEXATION OF ACCESSORY PARTS

The tendency toward consolidation often goes far beyond the organs immediately concerned. It seems as though a definite principle of organization grips all living structures which come close enough together to establish interrelations.

Many familiar examples will occur to you. The scales of the winter bud which protect the head of dogwood flowers expand at flowering time into the large white petaloid structures which make the dogwood so beautiful. The topmost leaves of the poinsettia take on the bright red which makes them desirable for Christmas decorations. The leaves below the head in the composites are brought into the organization and become analogous to sepals. The bracts subtending the flowers of grasses, becoming glumes, carry on the subsequent evolution of the group. In some grasses, where the spikelets are brought down close to bracts of a second order, these in turn are taken into the organization and become functionally comparable to glumes, as in the husk of maize or the hull of a sand burr.

Again when in composites the heads with their bracts are brought close together in the axils of lower leaves, these may become to all intents and purposes involucral bracts, and the compound head starts on a new line of evolution as in our common *Elephantopus* where the marginal ray flowers radiate, not from each head, but from the center of the cluster of heads, making the cluster analogous to a single flower.

In the pineapple, pulpefaction spreads from the ovaries through the bracts, and in some tropical varieties when fully ripened, to the main axis of the flower cluster as well.

The fact that our unified vertebrate head was achieved by the addition of gill arches and other organs originally separate entities has already been alluded to.

VI. THE NARROWING POSSIBILITIES OF EVOLUTION

As the evolution in any group proceeds the possibilities of diversification continually contract.

In the beginning, unrestrained by heredity, variations had free rein. The differences among unicellular organisms are more fundamental than those between the most diverse of the higher organisms. Blue-green algae, diatoms, ciliates, rhizopods, slime molds, and bacteria differ far more among themselves than do higher plants from higher animals. Among the bacteria, for instance, we have one group which has built its metabolism around the oxidation of sulfur, and another which oxidizes iron as a source of energy, while the protoplasm of all higher organisms is built on carbon chemistry.

The cytology, nuclear behavior, and consequently the heredity of all higher organisms, both plants and animals, is essentially the same. Otherwise, Mendel's law could not hold in guinea-pigs as in peas. But among unicellulars there are several entirely different types of cell organization the mechanism of which would preclude Mendelian inheritance.

Like most other laws of evolution, this narrowing path of progress finds a perfect analogy in human artifacts. Take the automobile. Those of you who can remember the early days of "horseless carriages" will recall the fundamental diversity of the early types. Beside gas buggies, there were steam and electric carriages. They were high-wheeled and low-wheeled with cushion tires, as well as pneumatic. Among the gas engines, some had one cylinder, some two, as well as others with four. A fundamentally different type of transmission survived for many years in the old Model-T Ford.

The history of the automobile gives a clear answer to the cause of the phenomenon. The diverse early types were eliminated by what amounts to natural selection. As the better types were proven out in use, it became impossible to sell the others until today all cars have approached so closely to a common standard of excellence that there is little to choose among them and the manufacturers fearing to adopt radical departures such as putting the motor in the rear have begun to waste their energies on inconsequential gadgets.

This is exactly the situation among organisms. In the early stages, protoplasm can go off into all sorts of experiments but as the type becomes fixed, heredity restricts variations to minor features and in the end we get mere diversity without any real difference. Many authors have called these later stages "speciation" and have emphasized the differences between speciation, evolution with a small *e* and Evolution of the larger characters, Evolution with a big E.

Dollo's well-known "law of the irreversibility of Evolution" is, of course, only a special case of the broader law of the narrowing possibility of variation.

Only two examples of the fundamental diversification which occurs in primitive groups may be given. Among primitive Notoungulata, a fossil order of hoofed mammals peculiar to South America, Simpson[4] found in the animals in a single quarry, i.e., those living together as one species in one time and at one place, characters upon which had been based seventeen species, seven genera, and three families.

The important consideration for us is: the criteria by which these families, genera, and species had been founded constitute valid distinctions for separating such groups among the later, more advanced members of this same order.

Among plants, the primitive family Anonaceae has more different kinds of floral structures than are to be found in any other one family, some of them not duplicated anywhere else among flowering plants. Yet indubitably all are closely related and properly placed in a single family.

This narrowing of the path of evolution seems to me to refute the claim of the geneticists that mutations are purely at random. You might as well argue about the random aberrations of a canal boat swinging on its tow-rope as compared with the course of a ship on the open sea, as to conclude that the random mutations of *Drosophila* tell us much about the evolution of insects.

I am not trying to minimize the importance of the mutations of *Drosophila*. They have been the key to wonderful advances in our

[4] SIMPSON, G. G. *Supra-specific variation.* Am. Nat. **71**: 247. 1937.

understanding of inheritance. But their relation to the evolution of insects has yet to be made known.

Those inclined to believe that changes significant for evolution occur at random would do well to ponder the implications of a paper by one of the greatest of geneticists, N. I. Vavilof, entitled, *Homologous variation.*[5] Assembling all the species and varieties of cultivated plants and their relatives in his experimental gardens, Vavilof observed that related types repeat over and over again the same series of characters, i.e., that homologous mutations had occurred in related types.

For instance, there are three groups of wheats. In the first group, *Triticum compactum* and *T. spelta* are closely allied to *T. vulgare* and repeat all the varieties of it.

The second group repeats the varieties of the first, e.g., there are varieties with white, red, and black ears; smooth and hairy ears; with white and red grains; winter and spring wheats; only beardless varieties are unknown.

The third group repeats the varieties of the second.

The similarity of the characters of the varieties of the three species of pumpkins, *Cucurbita maxima, C. pepo* and *C. moschata* interested Darwin who thought it accidental. Vavilof brings it under the reign of his law of Homologous variation. He shows further that the species of related genera show the same homology in their variation. Thus *Cucurbita* (pumpkin), *Cucumis* (cucumber), and *Citrullus* (watermelon), all have types with fruits round, oblong, flat and segmented; white, green, yellow, brown, black; monochrome, streaked, or spotted; each has both sweet and bitter varieties; and all show homologous variations in color and hairiness of petals.

He lists 34 homologous variations that have occurred in both wheat (*Triticum*) and Rye (*Secale*) and shows that the related genera *Agropyrum* and *Aegilops* though studied in less detail repeat in general the same series.

Following up his belief in homologous variation Vavilof sent out expeditions to search for varieties with characters known only in related types and was successful in finding them, very much as the chemists have filled the gaps in the periodic table of the elements.

The very homology in the mutations responsible for these characters by itself disposes of any supposition that they occurred at random. The same force must have acted independently in each of these parallel mutations.

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[5] Journ. Genetics **12**: 47–89. 1922.

While much of the convergence observed in plants and animals is clearly adaptive like the streamlined bodies of fishes, whales, seals, and manatees, most of the homologous characters dealt with by Vavilof are of no conceivable use to the organism and furnish no handle for natural selection to take hold of.

If they were useful their adaptiveness would necessarily be alternative. That is, natural selection would have preserved the more useful, for example, say leaves without ligules, and eliminated the others, leaves with ligules.

APPLICATION OF ORTHOGENESIS TO RESEARCH

I have listed some of the orthogenetic trends characteristic of organisms, and I have given data enough, I think, to prove their reality. Certainly more could be supplied to the extent that time and space permitted. Our further task is to apply such information to the problems of taxonomy.

One illustration of the use of those considerations, which occurred right here in our midst, was Hitchcock's treatment of the grasses. When he wrote the Gramineae for Gray's *Manual* in 1908, he used the old conventional system which put maize at the beginning, but in his *Genera of grasses* 1920, he adopted a system in accord with the orthogenetic trends here listed.

The difference in the mind of a student is very much the same as the enlightenment which suddenly dawned on all biologists when they first looked at organisms from the point of view of evolution. Like the theory of evolution itself it gave meaning and coherence to a mass of heterogeneous detail which before had been merely a burden on the memory.

If it be granted that every group of plants should be set into such an orthogenetic order and that the same should be done for animals, it must be recognized that the accomplishment of such an undertaking is a task not only of large magnitude but of considerable difficulty as well.

It might seem that, given the guiding principles, any child could make the applications. But it is not so. Although these orthogenetic trends are general characteristics of organisms, they are not organismal.

Each trend pursues its own course independent of all the other trends to which the organism is subject. One genus may have gone far in reducing the numbers of its parts but have made no progress in differentiation or in the fusion of parts. Another genus in the same family will show much differentiation but retain a primitive number of parts. That is, most close-knit groups of organisms can be arranged in various ways, depending on which of the orthogenetic trends present is used as the basis of classification. The problem of the taxonomist is to decide which of the trends present is most significant in the case in hand.

COMPETITION A POSSIBLE EXPLANATION OF ORTHOGENESIS

Before closing it will be well to take up the question of the cause of orthogenesis which I sidestepped at the beginning. I repeat that whether we understand it or not, orthogenesis must be accepted as the way of evolution. Yet we will never be satisfied until we penetrate the mystery and reveal the cause. It is unnecessary to say that I am not prepared to discuss this question with any degree of assurance or of specification, but there are some simple and well-known biological principles which may have a large bearing on the problem.

Why should there be a reduction in numbers of parts? Remembering that in the beginning of aggregation of cells—and to a considerable extent ever since—each individual cell maintains its own fundamental entity, we may ask why some should be eliminated. The answer comes to our lips almost automatically: It is the fittest, or more accurately, it is the most favorably placed, that survive.

In marvelling at coordination characteristic of multicellular plants and animals, we are apt to forget that their individual cells and organs are still in competition with each other. But we see examples of this fact every day in the buds of a tree which are laid down in numbers far beyond the possibilities of development. If some are removed, others which could never have developed in the presence of more favored competitors begin growth. It has been proven that the dormant buds are suppressed by the growth of the dominant ones. There is a metabolic gradient from the dominant leader backward and inhibiting hormones are sent back from the leader which prevent the growth of subordinate buds.

Similar metabolic gradients are characteristic of the animal body. They have been studied extensively by C. M. Child. He found that the orientation of the body is definitely controlled by these metabolic gradients. In simple planarians he was able experimentally to alter the metabolic gradients. By doing so, he was able to shift the head of the animal around almost at will.

No one has attempted to see how far metabolic gradients could be instrumental in directing the evolution of the race as they certainly do determine the development of the individual. In view of the similarity of the two cases there is no more occasion for assigning mystical agencies as the cause of orthogenesis than there is for bringing them into the explanation of the development of the individual.

Again a geneticist would say that the variations reported by Vavilof are homologous because the genetic constitution of related types is homologous. Given the closely similar gene complexes, closely similar mutations would be expected. This again is, however, only a restatement of the Law of the narrowing possibility of evolution.

Finally, it should be pointed out that these orthogenetic trends are largely unadaptive. In a few cases,such as the differentiation of the teeth, advantages to the organism may be made out. But generally, nothing of the sort can be imagined. For the most part, the adaptive sequences in evolution are superposed on the great orthogenetic trends but are entirely independent of them.

In the spurge family, Euphorbiaceae, for example, there is an orthogenetic series in the reduction from fairly typical flowers down to vestiges which could never be recognized as flowers if we did not have a complete series of integrating transitional forms. But no one could pretend that this change is advantageous. Alongside this, and entirely unrelated to it, is a modification of the plant body from that with typical leafy shoots into a series of leafless desert plants so similar to the cacti that they can be told apart only by technical characters. The independence of orthogenesis from environmental stimuli has been pointed out by many writers and there is no time to elaborate or further to illustrate here.

Our concern with the lack of adaptiveness in the main trends of evolution is its relation to the claims of the geneticists. In their belief, the orderliness of nature has been brought about entirely by the elimination of unfit mutations through natural selection.

Thus their case is entirely dependent on a demonstration that all trends observed in the evolution of all groups are adaptive, i.e., so useful to the organism that natural selection can take hold of them. It appears to me, as it has to others, that it is fairly easy to show that many of these trends are not so related.

I have alluded to a few instances of this but there is no time tonight to take up the evidence in detail.

So here I must rest my case.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

CHEMICAL SOCIETY

502ND MEETING

The 502nd meeting was held in Corcoran Hall, George Washington University, on Thursday, October 13, 1938, with President DRAKE in the chair. After the reading of the minutes, the President thanked the authorities of the University for the use of the meeting rooms. He next outlined to the membership the newly adopted plan of informal meetings to be sponsored by the Society. These meetings are to be held at irregular intervals, the object being the promotion of a fuller discussion of topics of considerable interest, particularly in connection with recent advances in chemistry, and to further the interests of special groups of chemists within the Society. The presentation of the subject matter at these meetings is to be informal, with an ample opportunity for a full and free discussion.

The following program was presented in three sections:

Analytical and Inorganic Chemistry, G. E. F. LUNDELL presiding:

BOURDON F. SCRIBNER: *The operation of a spectrographic laboratory.*—Both prism and grating spectrographs applicable to analytical work are commercially available. The prism types are of the Cornu or Littrow designs and the grating spectrographs of the Abney and Eagle mountings. The equipment for a laboratory should consist of a spectrograph costing $1,000 to $3,000 and accessory apparatus for excitation of spectra and examination of plates, costing from $300 to $1,000. In addition, a dark room for photographic processing and chemical facilities for preparation of samples are required.

The laboratory at the National Bureau of Standards is equipped with a large stigmatic grating spectrograph with a dispersion of 5 Ångstrom units per mm. and a large quartz Littrow spectrograph with accessories. The analyses made are (1) qualitative examination of samples for 55 to 70 elements, using a micrometer comparator; (2) rough quantitative analysis to ±10 per cent of the amount present, by direct comparison of the spectra of the unknown and a series of standards; and (3) refined quantitative analysis to ±3 per cent of the amount present using a densitometer and plate calibration.

The qualitative analysis, in which the concentrations of the elements present are estimated to a factor of 10, is applied to tests of purity, surveys preliminary to chemical analysis, identification of precipitates and concentrates, and comparison of museum specimens. Quantitative analyses in the range of concentrations below 10 per cent are made of tin and iron and of various constituents in steel, zinc, gold, refractories and water residues. (*Author's Abstract.*)

C. J. RODDEN: *Some observations on the chemistry of the rare earths.*—The abundance and sources of the rare earths with the general methods of separation were described with comments on the newer methods of isolating the rare earth elements. The physical and chemical properties were described showing the characteristic absorption spectra which were taken using but 0.3 to 0.5 ml. of solution. The use of the physical properties was indicated in the separation of the elements. The analytical chemistry up to the present was commented on with emphasis on the lack of methods for determining the separate elements. A survey of the general uses of these elements and their salts showed that the uses up to the present are meager. (*Author's Abstract.*)

W. D. URRY: *Isolation and measurement of small quantities of helium from radioactive decay.*—No abstract received.

Organic chemistry, S. N. WRENN presiding:

R. P. JACOBSON: *Structure of Sarsa-Sapogenin.*—From a study of a number of transformation products of sarsa-sapogenoic acid it is concluded that this substance contains in the side chain a γ-keto acid grouping attached to a substituted tetrahydrofurane ring. The side chain characteristic of the steroid sapogenins probably contains two tetrahydrofurane rings corresponding to the formulation first proposed by Tschesche and Hagedorn. (*Author's Abstract.*)

J. R. SPIES: *Chemical study of some constituents of the croton bean* (C. tiglium *L.*).—The author's work on the fish-poisoning and vesicant principle of the croton bean (*C. tiglium* L.) was reviewed. The aglycone fragment of the croton bean nucleoside (2-oxy-6-amino-purine-d-riboside) could not be deaminated with nitrous acid. The isogaunine from this nucleoside was deaminated, however, by refluxing with constant boiling hydrochloric acid. The xanthine so obtained was identified by analysis and by its transformation into bromocaffeine and ethoxycaffeine. Isoguanine crystallizes in rosettes as a hydrate containing one and one-half molecules of water of crystallization ($C_5H_5ON_5 \cdot 1\frac{1}{2}H_2O$). Isoguanine was cited as an unusual compound which apparently cannot be deaminated with nitrous acid but can be deaminated by refluxing with constant boiling hydrochloric acid. 2-oxy-6-8-diamino-purine was obtained from isoguanine by coupling it with 2-4-dichlorodiazonium chloride and reducing the red coupling compound. The sulfate, hydrochloride, acetate, carbonate, and picrate of 2-oxy-6-8-diamino-purine have been prepared and the formulas of these salts were determined. All of these salts are crystalline and exhibit birefringence when viewed with a polarizing microscope. Unlike isoguanine, 2-oxy-6-8-diamino-purine forms stable salts with both acetic acid and carbon dioxide. (*Author's Abstract.*)

HORACE S. ISBELL: *The nomenclature of the sugars and their derivatives.*—The various proposals which have been made for renaming the sugars show the need for the adoption of a definite policy for naming the higher sugars and their derivatives. E. Votocek (Collection Czechoslov. Chem. Communications **10**: 264, 1938) has suggested substituting *d* or *l* for Fisher's α and β or Elsner's *a* or *b* (Tollens-Elsner *Handbuch der Kohlenhydrate*, 4th Edition, page 391). Thus *d*-α-glucoheptose or *d*-gluco-*a*-heptose becomes *d*-gluco-*d*-heptose. In the latter name the first *d* refers to the configuration of the terminal asymmetric carbon, while the other *d* symbol refers to carbon 2. Hudson (J. Am. Chem. Soc. **60**, 1537, 1938) has suggested calling the same product *D*-gluco-*D*-gulo-heptose. In this name the first *d* or *l* symbol refers to the configuration of the terminal asymmetric carbon, while the second refers to the configuration of the fifth carbon. Obviously if both proposals are used for naming new sugars, much confusion will result. The suggestion made by C. D. Hurd (Symposium on the nomenclature of the sugars, American Chemical Society, Milwaukee, Wis., September 8, 1938) to drop the first term in Hudson's proposed name and to substitute a series of letters to represent the configurations of the higher carbons would offer a good compromise provided the customary *d* and *l* nomenclature was maintained by using as the first letter a *d* or *l* symbol. For example, *d*-α-glucoheptose could be called *d*-*d*-guloheptose. In this name the first symbol represents the configuration of carbon 6, while the term *d*-gulo represents the configuration of carbons 2, 3, 4, and 5. If the names for the higher sugars are to be based on the structurally related hexoses, the analogy should include the glycosidic carbon so that the alpha modifications of the heptoses will correspond to the alpha modifications of the structurally related hexoses. A classification of this character results by calling substances having like configurations for the glycosidic and ring-forming carbons alpha, and calling substances having unlike configurations from the glycosidic and ring-forming carbons beta. (*Author's Abstract.*)

Physical Chemistry, B. D. VAN EVERA presiding:

JACINTO STEINHARDT: *Solubility anomalies in crystalline proteins.*—The speaker reported on work performed in the Department of Physical Chemistry, Harvard Medical School, to be published in the Proceedings of the Symposium on Proteins held at Cold Spring Harbor in July 1938 in part, and also in the Journal of Biological Chemistry. No abstract was received.

GEORGE W. MOREY and JOHN S. BURLEW: *A filter autolcave for solubility measurements at elevated temperatures and atmospheric pressure.*—A new type of autoclave has been designed for the purpose of making precise solubility measurements in alkaline solutions at elevated temperatures and atmospheric pressure. With it a mixture of solid and liquid at a constant temperature can be stirred in a silver vessel and then filtered through a platinum felt, after which the filtrate is cooled and analyzed. The technique of such measurements is illustrated by data concerning part of the system $NaOH-Na_2CO_3-H_2O$ between 60 and 70° C. (A detailed description of this research appears in Am. J. Sci., **35A:** 285 (1938).) (*Authors' Abstract.*)

J. LESLIE JONES: *Kinetics of the thermal isomerization of cis-dichloroethylene.*—The kinetics of the gaseous thermal isomerization of *cis*-dichloroethylene into the *trans* form has been investigated over the temperature range 560–620° K. The change in the percentage composition of the gas phase was followed by condensing the product after a period of time and measuring the condensation vapor pressure of 0° C. A large scale calibration curve was employed to determine the percentage isomerization. The isomerization was found to be practically homogeneous after properly treating the reaction vessel. The rates of the forward and reverse reactions were found to be given by the unimolecular rate constants

$$k=2.5\times10^6e^{-27,100/RT}$$

and

$$k_r=2.7\times10^6e^{-26,000/RT}$$

respectively.

The simple theory of Hinshelwood is inadequate to account for such small values of the temperature independent factor, which is smaller than the usual value by a factor of 10^5. A theory is proposed to account for this abnormally slow reaction. It involved the loosening of one bond in the double bond, a relative rotation through 180° by one of the carbon atoms accompanying an inversion of one carbon atom and closure of the double bond. (*Author's Abstract.*)

FRANK C. KRACEK, *Secretary*

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JOURNAL
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PALEONTOLOGY.—Setigerites *nom. nov. a subgenus of* Productus.[1]

GEORGE H. GIRTY, U. S. Geological Survey.

By a regrettable oversight, the writer, in the October number of this Journal, published the name *Setigerella* as a subgenus of *Productus*, overlooking the fact, which has been recently called to his attention, that *Setigerella* had been used by Ehrenberg as long ago as 1872. *Setigerella* Girty is herewith replaced by *Setigerites* Girty, with the same connotation.

BOTANY.—*A New palm from Costa Rica,* Astrocaryum alatum.[2]

H. F. LOOMIS, U. S. Plant Introduction Garden, Coconut Grove, Florida. (Communicated by S. F. BLAKE.)

Botanists or others interested in the individual elements of the tropical forests through which passes the railroad leading from Puerto Limon to San Jose, Costa Rica, must have observed at frequent intervals in traversing the lowlands of the Province of Limon, a rather large palm with many graceful pinnate leaves, dark green above but pearl grayish-green on the underside. The trunk itself of the palm may be hidden completely by a varied growth of vines, aroids, ferns, and other small plants which find foothold in the accumulations of humus in the axils of the spiny leaf-bases which remain attached to the trunk long after the leaves have fallen. From the crown of leaves several densely packed clusters of large, spiny fruits droop on viciously spiny stems. Closer inspection reveals other details which show that the palm belongs to the genus *Astrocaryum*, represented in South America by many species but with only two species thus far recognized in Central America, *A. standleyanum* Bailey in Panama and *A. confertum* Wendl. in Costa Rica. Another species, found in Honduras, British Honduras, Guatemala and southern Mexico and long known as *A. mexicanum* Liebm., recently has been removed from *Astrocaryum* and made the type of the genus *Hexopetion*, and may be excluded from consideration here.

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[1] Received January 3, 1939.
[2] Received January 6, 1939.

Attempts to identify the Limon Province palm with any of the recognized species of *Astrocaryum* have failed, and the conclusion is forced that, in spite of its abundance and long accessability to collectors, it has remained undescribed. Hence, a technical account of the characters is presented and the specific name *alatum* is proposed in reference to the peculiar winged spines on the under side of the rachis of the leaves. *A. alatum* differs further from both *A. standleyanum* and *confertum* in having female flowers and fruits borne directly on the central spadix instead of on its lateral branches, these having the male flowers continuous from the base to or almost to the apex. The large, spiny, laterally compressed fruits also are distinctive.

In the neighborhood of Cairo, a few miles west of Siquirres, this palm is known only by the Spanish name "Coquito," this name being credited in Dahlgren's *Index of American Palms*, Field Mus. Nat. Hist., Bot. ser., 14, 1936, to the American oil palm, *Corozo oleifera*, in Costa Rica. The names "Zurubre," "Coyolillo," and "Coyolito," listed in the *Index* as applied to *Astrocaryum confertum*, were not recognized by the natives at Cairo as connected with any palm, hence it may be inferred that the range of *confertum* does not approach very close to Cairo.

Astrocaryum alatum Loomis, sp. nov.

Caudex solitarius 3–6 m altus 12–15 cm crassus non spinosus, basibus foliorum spinosis persistentibus; folia usque ad 6 dm longa, segmentis irregulariter contiguis, petiolo subtus spinoso spinis baseos applanatis usque ad 16 cm longis, rachi subtus spinosa spinis brevioribus lateraliter alatis; rami spadicis plusquam 40 omnino staminei; flores femineae in rachi spadicis inter ramos; fructus magnus spinosus apice subrostratus et inermis, in racemo compresso; semen obovatum apice rotundatum basi acutum extus fibrosum fibris complanatis ad foramina vergentibus.

Trunk solitary, 12 to 18 feet high and 5 to 6 inches in diameter, lacking spines but with spiny leaf-bases of the old leaves persistent to the ground; leaves numerous, 30 or more on mature palms, moderately arching, 18 to 20 feet long, the petiole accounting for half to a third of this length; pinnae seldom solitary, commonly in clusters of 2 to 15 segments completely joined, infrequently separated for a short distance above the base, the clusters of pinnae closely placed on the rachis, usually not over 2 inches apart; terminal 6 to 15 pinnae joined into a quadrangular group: one leaf-blade 11.5 feet long has 96 pinnae on the right side grouped in clusters as follows beginning at the base: 6–5–5–7–2–2–6–2–10–7–1–4–4–5–6–2–6–3–13; the 92 pinnae on the left side: 9–10–3–3–4–2–4–4–4–1–7–6–5–4–2–10–1–13; on this leaf the left basal pinna is 30 inches long, a pinna at middle of blade is 37.7 inches long, and the left terminal pinna is 8.2 inches long; individual pinnae, whether solitary or joined in groups, not over 1.2 inches wide; tips of pinnae obliquely erose-truncate; free lateral margins of pinnae with a few tiny brown terete spines; dorsal surface of pinnae dark green, glabrous,

Fig. 1.—*Astrocaryum alatum*, n. sp. *A*, forest palm in fruit, the leaf-bases persistent to the ground. *B*, section of inflorescence of type specimen, natural size. *C*, type inflorescence, less than a third natural size. (*A* by H. F. Loomis, *B* and *C* by O. F. Cook & C. B. Doyle.)

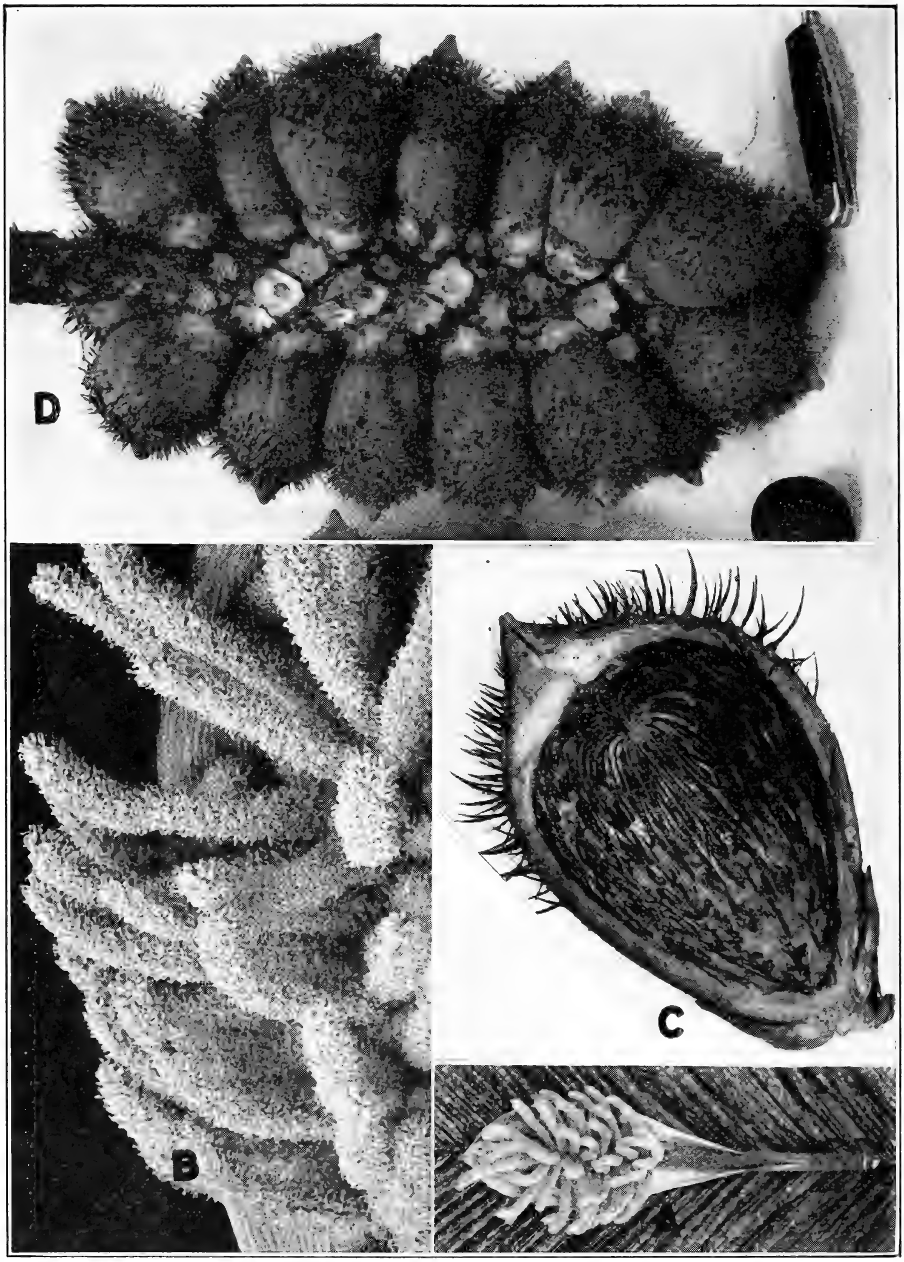

Fig. 2.—*Astrocaryum alatum*, n. sp. *A*, flowering inflorescence in spathe on a section of leaf, greatly reduced. *B*, close view of part of same inflorescence, less than half natural size. *C*, fruit cut to show seed, natural size. *D*, fruit cluster with some fruit removed to show arrangement and form of fruit, basal cups and spadix, less than half natural size. (*A* and *B* by H. Pittier, *C* by O. F. Cook & C. B. Doyle, *D* by H. F. Loomis.)

ventral surface silvery gray-green, densely scurfy and with minute erect spinules or glandular hairs scarcely visible without magnification but apparent to the touch; on young unexpanded leaves the tips of the pinnae on each side of the blade are joined or protected by a continuous strap-like element which separates from the tips when the leaf unfolds and hangs from the apex of the basal pinna, one such unbroken appendage which was collected is 8 feet 5 inches long and about a quarter of an inch wide, the outer end suddenly somewhat thickened and ending in a sheath-like hook with the surface and the outer margin of the strap below it beset with short, brown, ciliaceous spinules; leaf petioles from 6 to 10 feet long, smooth above and concave nearly to the blade, moderately spiny below at base which remains attached to the trunk long after the remainder of the leaf falls, the spines decreasing in number and size above, the basal ones black, simple, attaining 6.5 inches in length and a quarter of an inch across, in cross section lenticular, semi-circular or triangular; further out on the petiole, and especially on the rachis, the spines are flatter and develop a thin supplementary wing-like expansion on the basal half each side, its apical portion often acute and free from the spine, the outer margin sometimes slightly laciniate; spines deep brown, the lateral wings lighter, most spines somewhat reflexed, rising from the proximal side of a pulvinate swelling; rachis with a strong median rib above, ventral basal spines 1 to 1.5 inches long, outwardly decreasing in size and number and not present on the last foot or two of the rachis; spathe densely beset with suberect spines up to an inch long, the spathe splitting along the outer or lower side at flowering and afterward persisting and usually partly covering the fruit cluster; peduncle of inflorescence oval in cross section, less than 2 feet long and up to an inch broad, more densely spiny than any other part of the palm, the spines directed toward the inflorescence, less than half an inch long, flattened, the apical half often bent or even slightly undulate, the basal half densely woolly with lateral margins occasionally moderately winged, surface of peduncle between the spines also densely woolly; inflorescence short and thick, with over 40 simple branches attaining 7 inches in length and borne on a spadix 8 inches or more long; spadix and branches densely woolly between the flowers; branches completely occupied, except occasionally for a half inch at apex, by the male flowers which are closely crowded and in no consistent arrangement, basal or outer envelope of flowers small, chartaceous, with broadly triangular lobes reaching less than half way to the apex of the bud, open flowers not seen but in a detailed photograph taken many years ago the lobes of the inner envelope are not curved outward in the slightest, the elongate anthers borne on filaments twice as long; female flowers sessile, borne directly on the spadix among the simple branches but appearing to have no fixed relation to them, calyx and corolla distally provided with closely applied, ascending spinules, those on the calyx usually more strongly developed; on mature fruits the two basal envelopes are irregular produced at apex but are smaller and lacking the distinctly angular lobes of *A. standelyanum;* fruit clusters several to 8 or 9, infrequently suberect but usually drooping, composed of 25 to 50 large fruits attaining 3 inches in length and so tightly packed that their shape, and that of the enclosed seeds, is affected by mutual compression during growth and several flattened faces are produced on the basal portion of each fruit, distally the fruits are rounded, the surface rusty brownish-green with many erect, curved or straight spines not extending onto the produced, broadly conic tip; flesh of fruit white, firm, an eighth of an inch thick; seeds sometimes exceeding 2 inches in length, strongly oboval, sharply pointed at base, covered with coarse, very closely applied, irregularly ascending, branching fibers converging radially at the three pores; shell an eighth to a quarter of an inch thick, very hard; albumen white, hollow at center.

The foregoing description is based on material gathered in the forest and on palms examined there. In clearings where this palm has been allowed to remain, its aspect is quite different from that of the shade form, as it appears much more compact because the petioles and blades of the leaves are shorter, the latter with the groups of pinnae more closely placed on the rachis. Young palms of this species show a characteristic development of the leaves in that the pinnae almost never are separated; leaf-blades as much as four or five feet long remaining entire or at most with but one or two divisions on each side.

The type specimens deposited in the U. S. National Herbarium under numbers 474451–474457, were collected in the forest at Rio Hondo, Plains of Santa Clara, Costa Rica, altitude 100 meters, May 7, 1903, by O. F. Cook and C. B. Doyle under their number 584. Specimen 474452 is an inflorescence with flowers not quite old enough to open, the other specimens apparently are portions of a single leaf. Photographs of this species, made by O. F. Cook and C. B. Doyle in 1903 and H. Pittier in 1906, have been studied, parts of several of these being herein reproduced, and in addition the writer collected fruiting and leaf material at Cairo, Costa Rica, in 1937 and 1938 and sent it and seed to the Division of Plant Exploration and Introduction, Bureau of Plant Industry, U. S. Department of Agriculture, Washington, D. C. Plants from these seeds were distributed to plant experimenters in Florida in 1938 under P. I. number 123380 with the tentative name *Astrocaryum polystachyum*, a name which appeared in the Biologia Centrali-Americana in 1885 without description and which has not yet been thus supported.

Although it is too soon to be certain that this handsome tropical woodland palm will survive and become a part of Florida's subtropical horticulture the growth of these seedlings has been more rapid than with other species of the genus tested at the U. S. Plant Introduction Garden, near Miami, and promises well for the future.

PLANT PHYSIOLOGY.—*Hydrocyanic acid content of sorghum varieties.*[1]

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Sorghum[2] has long been known to be poisonous to animals under certain conditions. The quantity of cyanogenetic glucoside in this plant is one of the factors that determine its toxicity. A large number of sorghum varieties are grown in the United States for feeding to livestock, any one of which may be eaten by animals while in a con-

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[1] Cooperative investigation between the Pathological Division, Bureau of Animal Industry, and the Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture. Received November 18, 1938.

[2] (Sorghum vulgare, Pers.)

dition to produce poisoning. It is of interest to know to what extent the content of glucoside and, consequently the quantity of hydrocyanic acid, that may be liberated under appropriate conditions, is determined by the variety grown, and whether the differences observed are inherent in the variety or are due to responses to fluctuating environment.

Previous studies (8) have shown that the HCN content of a sorghum variety depends upon the part of the plant analyzed, the age of the tissues, and the growing conditions. Consequently, the relative HCN content of different varieties cannot be determined accurately with only a few samples grown at one point.

It seemed desirable to analyze sufficient samples of a considerable number of varieties grown at several places in the United States to overcome, insofar as possible, some of the discrepancies due to accidental or environmental factors that might affect determinations made from single collections and to determine the effect of certain environmental factors on the relative HCN content of the varieties. Samples were collected in two years, 1936 and 1937, and the analyses are summarized in this paper.

REVIEW OF LITERATURE

Other workers have reported data concerning the relative hydrocyanic acid content of different varieties of sorghum. Brünnich (2) reported 2 to 2.5 times as much HCN in "Imphee" as in Early Amber sorgo. Schröder and Damman (10), in the Argentine, found sorgo slightly higher in HCN than Johnson grass and nearly twice as high as in broomcorn (varieties not stated). Furlong (6) determined the HCN content of sorghum (Guinea corn) and millet at various stages of growth and found the former higher than the latter in ratios varying between 1.5 to 1 and 2.44 to 1. Francis (5) found less HCN in normal mature kafir leaves than in second-growth Sudan grass or in Sudan grass that was 10 inches high. The plants were, however, not of the same age or height and therefore not comparable. Willaman and West (12) published figures indicating that feterita produced considerably more HCN than Orange sorgo. Later (13) they reported figures showing that, except for plants 33 days old, Early Amber sorgo yielded slightly less HCN than "Southern Cane" under Minnesota conditions. Swanson (11) found the following quantities of HCN in the varieties stated: Kafir 36, sorgo 21, and Sudan grass 16 mg per 100 g of green tissue. With special treatment Red Amber yielded 59.5 and sorgo 48 mg of HCN. Collison (3) published an extensive comparison of the HCN content of different varieties. He analyzed plants 12 to 24 inches high of 17 varieties and two samples of mature hegari and feterita, all grown in Florida. The highest HCN content found was 3.8 mg per 100 g in mature hegari, which is extremely low. Mature feterita gave 3.6 mg. Of the 12 to 24-inch samples, hegari yielded the highest, 3.7 mg, Blackhull kafir was second with 3.3, feterita third with 3.2, and Brown kaoliang fourth with 3.1. Amber sorgo, Japanese Cane, and Napier grass yielded no HCN. Orange sorghum and a milo hybrid were low with 0.75 and 0.2 mg. respectively. Other varieties ranged from 1.6 to 2.6 mg. Piedallu (9) found Early Minnesota Amber sorgo and broomcorn richer in HCN than "S. douro" and Johnson grass. Finnemore and Cox (4), working in Australia, made a number of analyses of sorghum varieties, Sudan grass, and sorghum-Sudan grass hybrids, taking specimens of each at intervals during the growing period. Comparison of the figures for the green plants 64 days old shows the following order of HCN content: Feterita 75, Gooseneck sorgo 69, White African sorgo 45, Sumac sorgo 35, milo 33, Cowper sorgo 25, Collier sorgo 19, Saccaline sorgo 11, and Sudan grass 12 mg per 100 g green weight. The sorghum-Sudan hybrids gave 7 to 27 mg of HCN.

PRESENT INVESTIGATIONS

Environmental Conditions.—Sorghum samples were collected from six stations in the southern Great Plains in 1936 and 1937. The following representatives of the Bureau of Plant Industry grew the sorghums and collected the samples for analysis: for the Division of Cereal Crops and Diseases: J. J. Curtis at Akron, Colo., A. F. Swanson at Hays, Kans.; J. B. Sieglinger at Woodward, Okla.; J. C. Stephens at Chillicothe, Tex.; for the Division of Dry Land Agriculture: B. F. Barnes at Dalhart, Tex.; D. R. Burnham at Tucumcari, N. Mex. The sorghums were grown by the Division of Cereal Crops and Diseases in cooperation with the Colorado, Kansas, New Mexico, and Texas agricultural experiment stations and with the Division of Dry Land Agriculture, Bureau of Plant Industry. The seed used was from previous crops at the station, nearly all from self-pollinated (bagged) heads. Named varieties grown at different stations apparently were identical in type and origin, except for three varieties noted below, although some unconscious selection may have occurred in obtaining seed heads. The feterita samples were of the common type (C. I.[3] 182) at Hays, Woodward, and Tucumcari, and of the Spur variety at Chillicothe. The Spur variety is later and more leafy than common feterita. All of the hegari were identical in appearance, but the lot grown at Woodward (C. I. 750) was from a later introduction from the Anglo-Egyptian Sudan than the lot (C. I. 620) grown at the other stations. The Dwarf Yellow milo grown at Chillicothe (F. P. I.[4] 18684) appears to be identical with that grown at the other stations (C. I. 332) but the origin may be different. Three kafirs, Western Blackhull, Texas Blackhull, and Sharon are indistinguishable in growth habit or appearance but they were selected from farmers' fields of rather impure kafir in three different States. The wide differences in the rank for HCN content shown later for these three otherwise similar strains may indicate some inherent differences. However, they were not sampled under comparable conditions.

Altitudes.—The altitude in feet at the stations is as follows: Akron, Colo., 4,560; Hays, Kans., 2,000; Woodward, Okla., 2,002; Dalhart, Tex., 3,978; Chillicothe, Tex., 1,406; and Tucumcari, N. Mex., 4,158.

Soils.—The soil at Akron, Colo., is a dark-brown sandy loam underlain with clay at depths of 2 feet or more in most places. At Hays, Kans., the soil is a dark-gray to black loam of the Hays series underlain with a slightly lighter-colored clay loam and clay and is a typical chernozem soil. The soil at Woodward, Okla., is a sandy loam varying in thickness from 1 to 4 feet overlying a reddish clay subsoil and is classed as Amarillo sand. At Dalhart, Tex., the soil is a grayish sandy loam overlying a dark reddish-brown loam or clay loam of the Springer series and has been subjected to considerable dust blowing. The soil at Tucumcari, N. Mex., is a loose reddish-brown sandy loam of the Otero series that blows readily when unprotected by vegetation. The soil on Texas Substation No. 12, Chillicothe, Tex., is mostly a dark reddish-brown clay loam of the Vernon series.

Weather.—The mean monthly temperatures at the six stations for 1936 and 1937, compared with long-time averages for the five months, May to September, inclusive, are shown in Table 1. The precipitation for the same months is presented in Table 2. Temperatures were above average in 1936 and 1937 at all six stations, July and August being especially hot during the growing season. Precipitation for the five months was materially below average in both years at Hays, Kans., Dalhart, Tex., and Woodward, Okla., and in 1937 at Akron, Colo.,

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[3] C. I. refers to accession number of the Division of Cereal Crops and Diseases, formerly Office of Cereal Investigations.

[4] F. P. I. refers to accession number of the Division of Plant Exploration and Introduction, formerly Office of Foreign Plant Introduction.

TABLE 1.—MEAN MONTHLY TEMPERATURE IN °F, DURING THE GROWING SEASON IN 1936 AND 1937, AND THE AVERAGE MONTHLY TEMPERATURE AT SIX STATIONS

	May	June	July	August	September	Average
1936						
Akron, Colo.	60	70	79	74	63	69
Hays, Kans.	66	76	85	84	71	76
Dalhart, Tex.	65	75	79	79	67	73
Tucumari, N. Mex.	68	77	79	80	68	74
Woodward, Okla.	69	80	87	88	72	79
Chillicothe, Tex.	74	84	86	88	76	82
1937						
Akron, Colo.	59	66	75	77	65	68
Hays, Kans.	67	75	82	84	70	76
Dalhart, Tex.	66	73	79	80	70	74
Tucumcari, N. Mex.	68	74	80	82	72	75
Woodward, Okla.	71	77	86	86	73	79
Chillicothe, Tex.	75	80	86	86	77	81
Average						
Akron, Colo. (1912–1937)	56	67	74	71	62	66
Hays, Kans. (1893–1937)	62	72	79	78	69	72
Dalhart, Tex. (1906–1937)	62	72	78	76	68	71
Tucumcari, N. Mex. (1915–1937)	65	75	79	77	70	73
Woodward, Okla. (1914–1937)	67	77	82	81	73	76
Chillicothe, Tex.	71	80	84	83	75	79

and Chillicothe, Tex. The months of June, July, and August were very dry at Chillicothe in 1936. The precipitation at Tucumcari, N. Mex., was slightly above average both years.

The season of 1936 in the Great Plains was characterized by ex-

TABLE 2.—MONTHLY AND SEASONAL PRECIPITATION DURING THE GROWING SEASON IN 1936 AND 1937 AND AVERAGE MONTHLY PRECIPITATION

	May	June	July	August	September	Total
1936						
Akron, Colo.	3.51	3.04	1.85	2.17	3.03	13.60
Hays, Kans.	5.40	.60	.60	1.89	1.87	10.36
Dalhart, Tex.	3.67	2.44	1.49	.25	1.19	9.04
Tucumcari, N. Mex.	1.74	2.01	4.40	2.02	1.42	11.59
Woodward, Okla.	5.21	2.37	.23	.54	3.53	11.88
Chillicothe, Tex.	2.59	1.22	.46	0	13.67	17.94
1937						
Akron, Colo.	1.26	2.40	2.38	1.13	1.65	8.82
Hays, Kans.	1.73	1.98	4.28	2.58	1.71	12.28
Dalhart, Tex.	5.86	1.23	1.68	1.27	1.27	11.31
Tucumcari, N. Mex.	5.72	2.42	.87	.86	2.09	11.96
Woodward, Okla.	2.37	1.68	.51	2.28	3.91	10.75
Chillicothe, Tex.	1.50	2.63	1.81	2.91	.99	9.84
Average (24 or more years)						
Akron, Colo. (1908–1937)	2.85	2.40	2.57	2.19	1.46	11.47
Hays, Kans. (1906–1937)	3.07	3.77	2.71	2.95	2.02	14.52
Dalhart, Tex. (1908–1937)	2.82	3.08	2.30	2.58	1.43	12.21
Tucumcari, N. Mex. (1905–1937)	2.21	2.02	2.40	2.91	1.38	10.92
Woodward, Okla. (1914–1937)	3.47	2.96	1.84	2.44	2.75	13.46
Chillicothe, Tex. (1906–1937)	3.20	3.16	2.30	2.37	2.97	14.00

treme drought and high temperatures. Rains during May were ample for securing stands and maintaining early growth of sorghums. In general, the rains ceased about the first of June and sorghums having exhausted the available soil moisture, began showing the effect early in July at several stations. Showers at Akron, Colo., about July 11 and also prior to August 8 at Hays, Kans., prior to August 3 at Dalhart, Tex., and at Tucumcari, N. Mex., between August 25 and September 1, maintained or revived the plants somewhat. Plants were suffering from a shortage of moisture at Akron, Colo., on July 25; at Chillicothe, Tex., on July 14; at Tucumcari, N. Mex., on August 5; at Dalhart, Tex., after August 12; at Hays, Kans., on August 20; and at Woodward, Okla., on August 5. Later in the season, in September, ample rains fell at Chillicothe, Woodward, and Akron, but this moisture came too late to produce normal crop development, particularly in view of the early frosts. The crop at all stations thus suffered severely from drought.

In 1937, heavy rains occurred during the latter part of May at Dalhart and Tucumcari, but May rainfall was below average at the other four stations. Sufficient moisture was available for germination and fair early growth of the sorghums at all stations, but drought beginning after the middle of June at most of the stations affected the growth and development of the plants. Rainfall in July was below average at all stations except Hays and in August at all stations except Chillicothe. The crop was greatly retarded and stunted by drought at Dalhart, Tucumcari, and Hays, and growth was delayed at Woodward until rains came in September.

EXPERIMENTAL METHODS

Samples were collected at intervals during the growing season from most of the varieties studied. In some cases the number of collections was limited by a scarcity of material or by the condition of the crop but, wherever possible, samples were taken at intervals from the time the plants were 6 to 10 inches high until growth was stopped by frost.

During 1936 whole plants were sliced into small sections, the material intimately mixed, and duplicate 100 g samples weighed into pint preserving jars, covered with preservative, and shipped to the laboratory at Washington, D. C., where they were analyzed as soon as possible, 0 to 12 days, after arrival. After some experimenting with preservatives, 15 percent alcohol was used, and all figures obtained by the use of other preservatives in 1936 were discarded as inaccurate. It is now known that 15 percent alcohol is not an ideal preservative and that data obtained from samples preserved in it for longer than 7 to 10 days may be quite inaccurate. However, the data have a certain value for comparative purposes and indicate the relative proportions of HCN yielded by the different varieties.

In 1937, some important changes in collection and preservation were made with the result that the figures obtained from these collections are regarded as much more accurate than those for 1936. The plants were minced through a food chopper, mixed thoroughly, and the weighed samples preserved in mercuric chloride solution (1) in the proportion of 1 g of mercuric chloride to 100 g of fresh plant material. Experience with this preservative indicates that, in this strength, excellent preservation may be obtained for as long as six months. The samples were shipped to the laboratory and were analyzed four to six weeks after collection. The technique of analysis is described elsewhere (1).

In 1936 no moisture determinations were made on the collected samples and the figures obtained refer to the HCN content of green plant only. In 1937 moisture determinations were made on all samples except at Akron where the samples were only air-dried. For that year figures are available for the HCN content of fresh tissue and calculations are recorded on a moisture-free basis at all stations except Akron, where the air-dry basis was used.

VARIETAL DIFFERENCES

The average HCN content of all samples of the varieties collected in 1936 at each of the six stations is shown in Table 3. The figures are averages of eight collections made at Chillicothe, Tex., eight at Hays, Kans., four at Tucumcari, N. Mex., two each at Woodward, Okla., and Akron, Colo., and in part at Dalhart, Tex. Data from Akron are shown for two separate plantings, one on fallow land and the other on land in which moisture was very deficient, because Sudan grass had been grown the previous year. At Dalhart, samples were taken from two plantings made on June 4 and June 15. Five collections were made from the former and two from the latter planting.

The weighted average for each variety was calculated from the samples taken at the same time as were samples of Sumac sorgo. Since some samples were lost by breakage during transit and a few were discarded for insufficient preservation the figures for the corresponding Sumac sorgo samples were excluded from the averages. The varieties are listed in the order of comparative percentages. The

TABLE 3.—AVERAGE HYDROCYANIC ACID CONTENT OF 31 SORGHUM VARIETIES GROWN AT SIX STATIONS IN 1936

Variety	Samples	Hydrocyanic acid in 100 grams of fresh tissue								Weighted average of comparable samples		
		Akron, Colo.		Chillicothe, Tex.	Dalhart, Tex.		Hays, Kans.	Tucumcari, N. Mex.	Woodward, Okla.			
		On fallow	After Sudan grass		June 4	June 15				Variety named	Sumac in same tests[1]	Percentage of Sumac
	Number	mg	mg	mg	mg	mg	mg	mg	mg	mg	mg	mg
Feterita	41			49.7			42.3	16.9	81.0	44.5	33.5	132.8
Dawn kafir selection	13						31.9			31.8	27.7	114.8
Scarborough broomcorn	4								71.3	71.3	62.1	114.8
Wheatland	4	15.4	21.0							18.2	16.1	113.0
Chiltex	14			44.5						44.5	39.6	112.4
Western Blackhull kafir	16						33.8			33.8	30.3	111.6
Red Amber sorgo	14			39.8						39.8	37.8	105.3
Standard Blackhull kafir	4								66.4	66.4	63.1	105.2
White darso	4								66.1	66.1	63.1	104.8
Hegari	38			33.9	30.5	40.9			70.2	33.9	32.8	103.4
Sumac sorgo[1]	58	13.2	18.9	35.1	27.5	36.9	26.5	17.1	63.1	29.9	29.9	100.0
Sharon kafir	4								57.1	57.1	63.1	90.5
Finney milo	12							11.0	65.6	29.2	32.4	90.1
Honey sorgo	32			38.8	18.6	23.2		12.9		26.3	30.0	87.7
Atlas sorgo	37	9.2	12.0		21.2	27.5	30.0	11.0	49.7	26.8	31.3	85.6
Early Kalo	4	9.5	16.4							12.9	16.1	80.1
Evergreen dwarf broomcorn	4	7.9	17.7							12.8	16.1	79.5
Texas Blackhull kafir	24			29.1				9.0		22.5	28.7	78.4
Dawn kafir	12	8.1	15.9					13.6		13.1	16.8	78.0
Darso	27			28.9	14.9	26.8		17.8	65.9	30.1	38.9	77.4
Dwarf Yellow milo	44	13.5	14.9	30.2	16.3	18.5	25.6		55.8	27.2	36.3	74.9
Pink kafir	4	10.5	24.6							12.0	16.1	74.5
Kansas Orange sorgo	52	7.1	18.4	26.9	19.9	24.0	24.0	12.7		21.4	31.1	68.8
Acme broomcorn	11				17.5			14.4		15.2	22.6	67.3
Leoti sorgo	30	7.6	10.5		12.1	11.6	20.4			16.4	26.1	62.8
Freed	4	7.1	12.2							9.6	16.1	59.6
African Millet sorgo	25			24.9	14.2	19.2				21.4	36.3	59.0
Quadroon	12			22.1						21.4	36.9	58.0
Black Amber sorgo	4	9.0	8.1							8.5	16.1	52.8
Sunrise kafir	14				13.9	15.8			30.5	18.6	39.0	47.7
Early Red kafir	14				11.7	10.0				11.4	29.6	38.5

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[1] Early Sumac sorgo at Akron, Dalhart, and Hays.

number of samples of some varieties was limited and the reliability of the average HCN contents shown for these varieties is questionable. Comparable averages based upon 10 to 16 or more samples, however, should indicate the relative HCN content of the varieties with considerable dependability. The data from Woodward, Okla., are based on only two collections made on August 17 and 29 at a time when the HCN content of the plants was at a high seasonal level. At the other stations, with the exception of Akron, the data include those from collections made in September and October when the HCN content normally is low.

A considerable difference in the HCN producing capacity of the varieties is indicated in Table 3. Varieties like feterita, Chiltex, and hegari tended to produce relatively large quantities, and Leoti sorgo, Early Red kafir, Dawn kafir, and Acme broomcorn produced one-quarter to one-third as much. If the lethal level of HCN in fresh sorghum for sheep be assumed as about 20 mg per 100 g, in accordance with the suggestion of Hindmarsh (7), which in the main agrees with some unpublished results of the Bureau of Animal Industry, then the average sample of 20 of the 31 varieties would be likely to produce poisoning if livestock gained access to the growing plants. However, since the figures are averages, and include data from mature plants that normally contain little HCN, it should be emphasized that any and all of the varieties listed may be highly dangerous at certain stages of growth, and none is to be regarded as always nontoxic.

The quantities of HCN in the varieties do not show the same relations when the varieties are grown at different stations. At Chillicothe, Honey sorgo was a tenth higher than Sumac sorgo, a fourth lower at Tucumcari, and a third lower at Dalhart. Feterita was only slightly lower in HCN than Sumac sorgo at Tucumcari but was distinctly higher at Chillicothe, Woodward, and Hays. HCN in Atlas was two-thirds to four-fifths that of Sumac sorgo except at Hays, where it was 13 percent higher. Darso was a little higher than Sumac sorgo at Woodward and Tucumcari but only half as high in the June 4th planting at Dalhart.

The ranking of varieties in order of HCN content in Table 3 is not in general agreement with opinions based upon casual reports of sorghum poisoning on farms. Most cases of sorghum poisoning appear to occur in fields of kafir and sorgo. The Black Amber variety is the leading sorgo in the northern half of the United States, including South Dakota, Nebraska, Colorado, and northern Kansas, sections where poisoning seems to be of frequent occurrence. Analyses of

Black Amber from Akron show it to be relatively low in HCN. This, however, may be a result of a more advanced stage due to the relatively early maturity of the variety. Reports of poisoning in animals from eating hegari are rare but this may be due to the fact that very little hegari is grown north of Oklahoma. Milo and broomcorn usually are headed from standing stalks which are left in the field. The fields of these sorghums often are pastured after harvest, and reports of poisoning on milo and broomcorn are extremely rare, although analyses indicate that both contain toxic quantities of HCN at times. It is probable that sufficient seed and mature leaves and stalks are consumed along with the young second growth leaves so that dangerous quantities of the latter are avoided.

Table 4.—HCN content in mg per 100 g of dried leaves and green plants of sorghum varieties collected at Chillicothe, Tex., Sept. 11, 1936

Variety	Moisture content of dried leaves	HCN content		
		Dried leaves	Whole green plant	
			Wet basis	Dry basis[1]
	percen	mg	mg	mg
Sumac sorgo	9.33	91.6	48.1	192.4
Darso	9.39	86.9	29.1	116.4
Spur feterita	8.94	71.1	72.8	291.2
Hegari	9.50	59.1	51.2	204.8
Chiltex	8.55	54.8	59.1	236.4
Texas Blackhull kafir	9.69	52.5	36.2	144.8
Kansas Orange sorgo	10.34	43.2	43.1	172.4
Red Amber sorgo	8.77	40.1	32.7	130.8
Sourless sorgo	8.72	38.5	35.0	140.0
Dwarf Yellow milo (F.P.I. 18684)	6.64	31.2	38.3	153.2
Honey sorgo	6.96	24.9	51.3	205.2
Quadroon	8.32	20.6	30.0	120.0

[1] Calculated on the basis of the assumed approximate average moisture content of 75 percent in the green plants.

Table 4 shows a comparison of the HCN content of fresh green plants and dried leaves of the same varieties collected at Chillicothe, Tex., on September 11, 1936. Samples were taken of whole plants and preserved for analysis and, at the same time, leaves of the same varieties were selected and dried. The varieties are listed in order of the HCN content of the dried leaves. Sumac sorgo was highest in HCN in the dried leaves and fifth in content in the green plants. Spur feterita was highest on the basis of the green whole plants, but was third in HCN content of the dried leaves. Darso, which was lowest in HCN in the green whole plants, was second high on the basis of the dried leaves. While the fresh plants of hegari and Honey sorgo had about the same HCN content, the dried hegari was more than twice as high as Honey sorgo. Chiltex was second in the green whole plant and fifth with respect to the dried leaves. These data suggest not only that the comparative quantities of HCN differ in the dried leaves as compared with the whole plant but also that varieties may lose HCN at different rates or in varying degrees on drying. Thus, hegari and Chiltex lost a larger percentage than did Sumac sorgo and much less than did Honey sorgo. Darso lost comparatively little, while Quadroon, which was about equal to darso in the green state, lost the greater part of its HCN when dried.

The toxicity of the dried samples is of interest. Several of the varieties were force-fed to sheep. Feterita, hegari, and darso, fed in doses calculated to contain from 1.5 to 2.5 minimal lethal doses of HCN, produced serious symptoms of poisoning from which the animals recovered after treatment. Texas Blackhull kafir produced symptoms of poisoning when fed forcibly in doses of 0.9 to 1.1 m.l.d. from which the sheep recovered without treatment. It appears that dried sorghums containing somewhat less than 52.5 mg of HCN per 100 g are potentially dangerous in hay. Of the varieties listed in Table 4, Dwarf Yellow milo, Honey sorgo, and Quadroon might possibly be considered only slightly dangerous while the other varieties contained sufficient HCN to produce more or less serious symptoms, and several of the varieties were sufficiently high in HCN to cause very serious effects, if not death, if eaten in the quantities usually consumed at a single feeding under the conditions of the above experiment.

During the season of 1937 attention was concentrated on a few varieties. Feterita, Sumac sorgo, hegari, and Dwarf Yellow milo were grown at each station. Texas Blackhull kafir was grown at Chillicothe, Dalhart, and Tucumcari, Western Blackhull kafir was grown at Hays, Sharon kafir at Woodward, and Dawn kafir at Akron. The first three varieties of kafir are indistinguishable morphologically and in time of maturity, although it is possible that they may differ in HCN content. The data in Table 3 suggest that these three kafirs may differ in HCN content. Collections of Sudan grass were made at Akron, Chillicothe, and Woodward. Hegari was sampled as a whole plant. With the other varieties, the whole plant was sampled until the flag leaf appeared. After that only the leaves were sampled, as it had been ascertained that the stalks contain so little HCN that they are not important in animal poisoning. Collections were continued at most of the stations until frost occurred. The data are fairly complete for the different varieties from the seedling to the ripe stages of growth. Comparable collections of feterita and Sharon kafir were also made from the plots grown by the writers at Arlington Farm, Arlington, Va. Some of these samples were analyzed immediately upon collection, as well as after preservation in mercuric chloride solution. The results presented in Table 5 represent the averages for each variety at each station, with a general average for all of the stations. Dawn kafir, grown only at Akron, is not included in the averages for the kafirs. The data are calculated to mg of HCN per 100 g of dried plant, air-dried in the case of Akron. These figures also were calculated to a common basis, taking Sumac sorgo again as a standard and calculating each station separately.

TABLE 5.—HCN CONTENT OF SORGHUM VARIETIES AT SIX STATIONS IN 1937

Variety	HCN content of 100 g dry matter							
	Akron	Chillicothe	Dalhart	Hays	Tucumcari	Woodward	Average	Percentage of Sumac
	mg	mg	mg	mg	mg	mg	mg	mg
Young Whole Plants								
Feterita	200.3	156.3	212.9	199.1	176.4	150.9[1]	182.6	95.5[5]
Sumac sorgo	203.2	171.8	239.3	216.6	165.7	138.4[2]	172.5	100.0
Hegari	121.6	107.2	209.6	181.4	183.2	144.2[2]	157.8	84.4
Dwarf Yellow milo	182.2	112.0	168.8	158.9	128.2	107.2[3]	142.8	75.6
Kafir	133.2[1]	114.5	107.6	138.0	114.7	88.4[2]	112.6[4]	61.7[4]
Sudan grass	161.1	121.2	—	—	—	48.2	110.1	58.9
Fully-developed Leaves								
Feterita	197.1	133.4	156.6	217.1	141.5	146.3	165.3	95.2
Sumac	213.1	202.3	152.7	219.8	80.4	—	173.6	100.0
Hegari	193.0	161.6	—	208.1	110.7	—	168.3	96.9
Dwarf Yellow milo	154.9	72.6	79.3	123.1	64.4	—	98.8	56.9
Kafir	166.6[1]	69.7	50.5	136.9	87.3	—	86.1[4]	59.6[4]
Average of all	175.1	138.4	152.8	179.9	125.3	111.0	147.1	—

[1] 3 collections.
[2] 6 collections.
[3] 4 collections.
[4] Dawn kafir, not included in averages.
[5] Adjusted to comparable samples of Sumac sorgo from Woodward.

In general, the results are similar to those obtained in 1936. Feterita hegari, and Sumac sorgo are high in HCN while milo and the kafirs are low. The principal change is the change in position of Sumac sorgo from third place among the varieties grown at more than one station in 1936 to first in 1937 both for young whole plant and for leaves. This relationship was maintained at all of the stations except at Tucumcari, where Sumac was lower than both hegari and feterita both as young whole plant and as leaves, and at Dalhart where, as leaves, it was below feterita. At all stations milo and the kafirs were relatively low except Dawn kafir, grown only at Akron, Colo., the average for which is not strictly comparable with the averages for other varieties grown at five or six stations.

Selection for low hydrocyanic acid content in Dakota Amber sorgo by C. J. Franzke, of the South Dakota Agricultural Experiment Station, Brookings, S. Dak., has been in progress for some years. Seed of a strain (No. 39-30-S) having a low HCN content was obtained from Mr. Franzke and planted at Dalhart, Tex., in comparison with the unselected Dakota Amber variety. Three collections of the two strains were analyzed and the results are shown in Table 6 in comparison with feterita and Sudan grass collected the same day. The Sudan grass was older than the sorghum varieties and, consequently, not strictly comparable.

TABLE 6.—HYDROCYANIC ACID CONTENT OF A DAKOTA AMBER SORGO SELECTION 39-30-S IN COMPARISON WITH THAT OF UNSELECTED DAKOTA AMBER, FETERITA, AND SUDAN GRASS GROWN AT DALHART, TEX. IN 1937

Variety	HCN content in 100 g of oven-dry tissue		
	Whole Plants		Leaves
	August 6	August 13	September 10
	mg	mg	mg
Dakota Amber sorgo (selection 39-30-S)	161.7	61.7	66.8
Dakota Amber sorgo (unselected)	217.1	204.8	181.3
Feterita	254.3	232.3	200.6
Sudan grass	77.6	67.5	9.3

The first collection was made on August 6, 1937, when the sorghum plants were about 14 inches and the Sudan grass about 24 inches in height. The data indicate that the selected strain, which also was earlier in maturity, is distinctly lower in HCN than unselected Dakota Amber and, in some cases, may be as low as Sudan grass. Despite this, the HCN content of the August 6 sample of selection No. 39-30-S (31.7 mg on a green basis) was above the supposedly toxic limit of 20 mg.

ENVIRONMENTAL DIFFERENCES

The relative standing of the various stations with reference to the quantities of HCN found in the plants in 1936 was determined by averaging the determinations shown in Table 3 of Sumac (or Early Sumac) and Dwarf Yellow milo (or Finney milo) at each station. The average HCN contents thus determined were as follows: Woodward, 60.0; Chillicothe, 32.7; Akron, 30.2; Hays, 26.1; Dalhart, 24.8; Tucumcari, 14.1. The high values at Woodward are due in part to the limited number of collections made only in August at a stage when the HCN content was high. A direct comparison of differences between stations was obtained in 1937 from collections of whole plants of hegari made during an eight-week period between July 20 and September 17. The data are shown in Table 7. On the basis of the average HCN content of hegari at five stations, Tucumcari and Dalhart are highest and Woodward and Akron lowest. The comparative ratings for the stations in 1937 show some striking differences from those for 1936 (Table 8). Tucumcari moved from sixth to first place, Dalhart from fifth to second, Woodward from first to sixth, Chillicothe from second to third, and Akron from third to fifth. While comparable figures for whole hegari were not available from Hays in 1937 the general result from all varieties shows that Hays was running slightly above Akron, which would place this station in fourth place, as in 1936.

Table 7.—Hydrocyanic acid content of whole plants of hegari grown at different stations in 1937

Station	Number of samples	Age at first sample	Average HCN content[1]
		Days	mg
Tucumcari, N. Mex.	16	34	188.0
Dalhart, Tex.	14	36	175.1
Chillicothe, Tex.	14	35	140.0
Akron, Colo.	16	37	117.0
Woodward, Okla.	16	38	114.4
Average		36	146.8

[1] Mg per 100 g dry matter.

Table 8.—Relative rank of stations for HCN compared with precipitation and temperature

Station	Altitude (feet)	Relative rank for HCN content of sorghum		Precipitation (inches)				Mean temperature °F. July and August	
				July and August		June, July and August			
		1936	1937	1936	1937	1936	1937	1936	1937
Tucumcari, N. Mex.	4,158	6	1	6.42	1.73	8.43	4.15	79.5	81.0
Dalhart, Tex.	3,978	5	2	1.74	2.95	4.81	4.18	79.0	79.5
Chillicothe, Tex.	1,406	2	3	0.46	4.72	1.68	5.58	87.0	86.0
Hays, Kans.	2,000	4	4	2.49	6.86	3.09	3.71	84.5	83.0
Akron, Colo.	4,560	3	5	4.02	3.51	7.06	5.91	76.5	76.0
Woodward, Okla.	2,002	1	6	.77	2.79	3.14	6.40	87.5	86.0

These changes may be in part correlated with the rainfall for the months of July and August, the period in which rainfall would be most likely to affect the averages for HCN in the sorghums. In both years the two highest-standing stations were relatively low in rainfall, but otherwise little relationship between rainfall and HCN is evident. It is possible that, above a critical point, available moisture may lead to HCN production by stimulating the growth of new tissue. In plants that have not begun to produce heads, HCN production in excess of utilization may be correlated with rapid growth of new tissues.

In this connection the results obtained with feterita and Sharon kafir grown at Arlington, Va. in 1937 are of interest. The crops were grown on low flat land with a high water table, and the season was unusually wet. At no time was the ground dusty and much of the time the surface was moist to muddy. Under these conditions the average HCN content for young whole feterita plants was 204 mg per 100 g of dry matter as compared with the average of 182.6 for the western stations (Table 5), and for leaves 82.8 mg for Arlington and 165.3 mg for the western stations. The average HCN content of young whole Sharon kafir plants was 128.2 mg as compared with 88.4 mg for whole young plants from Woodward, and 40.1 mg for leaves, against an average of 86.1 mg for kafirs grown at four western stations. Samples of leaves of Sharon kafir were not taken at Woodward.

It thus appears that young plants grown on the Atlantic seaboard under adequate moisture conditions may still produce quantities of HCN comparable with those grown under drought conditions on the Great Plains, but the HCN production appeared to fall off more sharply when the plants began to mature.

No correlation between altitude and HCN content of sorghums grown at a station could be drawn, and the same is true of the mean temperatures for July and August of both years.

SUMMARY

Plant and leaf samples of 33 sorghum varieties grown at one or more of six stations in the Great Plains area in 1936 and 1937 were analyzed for HCN content at various stages of growth. It appears that any variety tested may contain sufficient HCN at times to be toxic to animals. Feterita, hegari, Chiltex, and Sumac sorgo tended to be high in HCN; milo, darso, Atlas sorgo, and Kansas Orange sorgo were intermediate; and Leoti sorgo and "African Millet" sorgo and a selected strain of Dakota Amber sorgo were rather low in HCN. Varieties of kafir showed wide variation, some being high and others low in HCN. The comparative rank among the stations in average

HCN content of the samples was different in the two seasons. The HCN content of the sorghums showed some tendency to be high where summer precipitation was lowest but there was no consistent relation between HCN content of sorghum and differences in temperature. Young feterita plants grown under abundant moisture conditions at Arlington, Va., contained as much HCN as the average for the six Great Plains stations where drought was severe.

The HCN content (calculated on a dry matter basis) of dried leaves of sorghum varieties ranged from about 12 percent to 75 percent of that of the whole green plant.

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ZOOLOGY.—*Predaceous nematodes of the genus* Aphelenchoides *from Hawaii.*[1] J. R. CHRISTIE, U. S. Bureau of Plant Industry.

In a recent publication Linford and Oliveira[2] pointed out that certain species of the nematode genus *Aphelenchoides* Fischer, 1894 are predaceous and number among their prey other nemas including the root-knot nematode, *Heterodera marioni* (Cornu, 1879) Goodey, 1932. These investigators have been able to rear five species of predaceous *Aphelenchoides* on agar cultures where their feeding habits could be studied. A population of some other nematode was first established on these cultures to provide food for the predators. Linford and

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[1] Received February 3, 1939.

[2] Science **85**: 295–297. 1937.

Oliveira kindly forwarded to the writer cultures of these five *Aphelenchoides* species and the following descriptions and drawings are based on a study of the material thus provided. As the bionomics of these nematodes are being studied by the above mentioned investigators the present paper deals exclusively with taxonomy and morphology.

The species described herein belong to a group for which "long tailed" *Aphelenchoides* is perhaps an appropriate designation. The first of this group to be described was *Aphelenchoides longicaudatus* (Cobb, 1893) Goodey, 1933. This species is poorly characterized and probably unrecognizable but in one particular it seems to differ from all the subsequently described "long tailed" species including those described in the present paper: the length of the tail is at least twice as great as the distance from the vulva to the anus. The other species that have been added to this group are as follows: *A. tenuicaudatus* (de Man, 1895) Goodey, 1933, *A. winchesi* (Goodey, 1927) Filipjev, 1934, *A. demani* (Goodey, 1928) Goodey, 1933, *A. elmiraensis* van der Linde, 1938, and *A. oswegoensis* van der Linde, 1938.

Linford and Oliveira tentatively identified one of their species as *A. tenuicaudatus.* This identification apparently is correct. A second species is described herein as *A. winchesi* var. *filicaudatus,* n. var. The remaining three species are regarded as new and for these the names *A. linfordi,* n. sp., *A. oliveirae,* n. sp. and *A. oahuënsis,* n. sp. are proposed.

There is considerable resemblance between females of some of these predacious *Aphelenchoides* and the female of *Seinura mali* Fuchs, 1931. The similarity of the stylet, the esophageal bulb and the tail is noticeable. Fuchs neither mentions nor figures the esophageal glands. On the other hand the tail of the male of *S. mali* differs conspicuously from that of all the predaceous species of which the male is known. Precisely what characters serve to differentiate the genus *Seinura* from the genus *Aphelenchoides* is not altogether clear to the writer but on the basis of Fuchs' description probably the male tail constitutes the most important differentiating character. If this is true none of the species described in the present paper belong in the genus *Seinura.*

As these five species of predaceous *Aphelenchoides* are quite similar in structure a few comments on their common morphological characteristics seem pertinent. Beginning at or somewhat anterior to the anus the body of the female tapers more or less evenly and ends in a long, pointed, conical tail. The longitudinal, cuticular modifications that define the so-called lateral fields of *A. parietinus* and *A. fragariae* were not observed. If such cuticular modifications occur they are very indistinct. The head is more or less distinctly set off and is divided into six, slightly elevated, lip-like sectors. These lip-like elevations are slightly more conspicuous on some of the species (i.e. *A. tenuicaudatus*) than on others. The stylet is divided into an anterior, conical part and a posterior, cylindrical part with the anterior opening on the ventral side. At the junction of these two parts the stylet is encircled by a structure somewhat resembling the so-called guiding ring of dorylaims. This structure is most conspicuous in *A. tenuicaudatus* but is present and more or less distinct in all the species. The esophageal gland mass is exceptionally large. It is composed of a large gland, presumably the dorsal, constituting the posterior two-thirds or more of the mass and a pair of smaller glands, presumably the subventrals, constituting a greater part of the anterior third of the mass. The nucleus of the largest gland was seen in all the species but the nuclei of the smaller glands were more difficult to observe in toto preparations. Secretion from the esophageal glands fills a considerable area in the anterior part and a lesser area in the posterior part of the bulb with more or less secretion between these two areas just dorsal to the wall of the central lumen. The bulb is relatively large and somewhat elongated but varies considerably in shape, depending on the amount of secretion contained and the state of muscular contraction. Near the anterior end of the bulb the wall of the esophageal lumen is distinctly interrupted by at least one, or perhaps several, minute openings. Although undoubtedly present, phasmids were not observed, as a special technic necessary to make them visible was not employed.

The outlines of the drawings and all measurements were made on specimens killed in a 5 per cent solution of commercial formalin (about 2 per cent formaldehyde) heated to 70°C. Living specimens were used to determine many of the morphological details.

Aphelenchoides winchesi (Goodey) Filipjev var. **filicaudatus**, n. var.

Synonymy.—*Aphelenchus winchesi* Goodey. Jour. Helminth. **5**(4):2–7, figs. 1–5. 1927. *Aphelenchoides winchesi* (Goodey). Filipjev, *Harmful and useful nematodes in rural economy.* Moskva, Leningrad. p. 236, fig. 203, G-H. 1934.

Measurements.— ♀ : Length 800 to 880μ; width 23 to 26μ; length of esophagus, 80 to 86μ; length of tail, 138 to 187μ; α, 31 to 35; β, 9.7 to 10.6; γ, 4.5 to 6; V, 61 to 66%.

Description.—Male unknown. Female (Fig. 1,B) with cuticular striae fine, moderately obscure. Head region relatively short, only faintly set off. Stylet 18 to 19μ, without basal knobs. Excretory pore from opposite middle to opposite posterior margin of esophageal bulb. Tail tapers more or less evenly and ends in a long filiform process. Anus very inconspicuous. Intestinal lumen between vulva and anus often wide and filled with fecal material. Vulva relatively inconspicuous; postvulvar uterine sac very short; ovary outstretched, frequently extending nearly to nerve ring. Eggs 59 to 65μ by 19 to 21μ.

Habitat.—Soil.

Locality.—Island of Oahu, Territory of Hawaii, U.S.A.

Comparisons and affinities.—This variety, based on females only, differs from the type species in having (a) a longer tail (120 to 130μ in type, 138 to 187μ in present variety), (b) a shorter stylet (24 to 27μ in type, 18 to 19μ in present variety) and a somewhat more anteriorly situated excretory pore ("a short distance behind level of bulb" in type, from about opposite middle to about opposite posterior margin of bulb in present variety). In addition the vulva seems to be situated somewhat more anteriorly (at 70 to 75% in type, at 61 to 66% in present variety). As Linford and Oliveira had cultures of this variety under observation for a considerable period and neither they nor the present writer observed males, one may conclude that at least males are very rare. This constitutes another difference between the type species and the present variety.

Aphelenchoides tenuicaudatus (de Man) Goodey

Synonymy.—*Aphelenchus tenuicaudatus* de Man. Trans. Liverpool Biol. Soc. **10**: 77–81, pl. 3, figs. 1, 1a, 1b, & 1d, pl. 2, fig. 1c. 1895. *Aphelenchoides tenuicaudatus* (de Man). Goodey, *Plant parasitic nematodes and the diseases they cause.* London, p. 250, fig. 111. 1933.

Measurements.—♂: Length, 650 to 720μ; width, 17 to 21μ; length of esophagus, 76 to 87μ; length of tail, 45 to 56μ; α, 34 to 40; β, 7.8 to 8.7; γ, 12.5 to 15.5. ♀: Length, 930μ to 1 mm; width, 25 to 30μ; length of esophagus, 84 to 93μ; length of tail, 92 to 104μ; α, 31 to 39; β, 10 to 11.2; γ, 9 to 10; V, 70 to 74%.

Description.—Cuticular striae fine, moderately obscure. Head region (Fig. 2,A) set off about as in *A. parietinus*, lip-like elevations relatively conspicuous. Stylet 14 to 16μ long in males, 16 to 19μ long in females; without basal knobs. Excretory pore opposite posterior end of esophageal bulb. Tail of female long and slender, tapering more or less evenly. Postvulvar uterine sac usually extending about one-half distance from vulva to anus but somewhat variable in size and shape. Ovary outstretched and extending past posterior end of esophageal glands, sometimes nearly to nerve ring. Tail of male (Fig. 2,B) somewhat similar in shape to that of female but tapering less abruptly in anterior two-thirds, then narrowing abruptly with posterior third in the form of a more or less slender terminal spike. Four pairs of papillae present; one pair about 8 to 10μ in front of anus and nearly ventral, one pair opposite or slightly posterior to anus, and 2 pairs, 4 or 5μ apart, near middle of tail. Spicule 18 to 20μ long with shape as shown in Figure 2,B.

Habitat.—Soil.

Locality.—Islands of Oahu and Maui, Territory of Hawaii, U.S.A.

Comparisons and affinities.—The writer's material agreed fairly closely with both de Man's and Goodey's descriptions. The most conspicuous difference was the length of the stylet which, in females, measured only 16 to 19μ as against 24 to 27μ in de Man's material.

A. elmiraensis resembles *A. tenuicaudatus* more closely than it resembles any other described species. It differs in the length of the tail in both sexes and in the length of the stylet. The stylet is only 10μ long and γ, in the female, is about 4.5, while in the male tail of *A. elmiraensis* the terminal portion posterior to the papillae is considerably longer than in *A. tenuicau-*

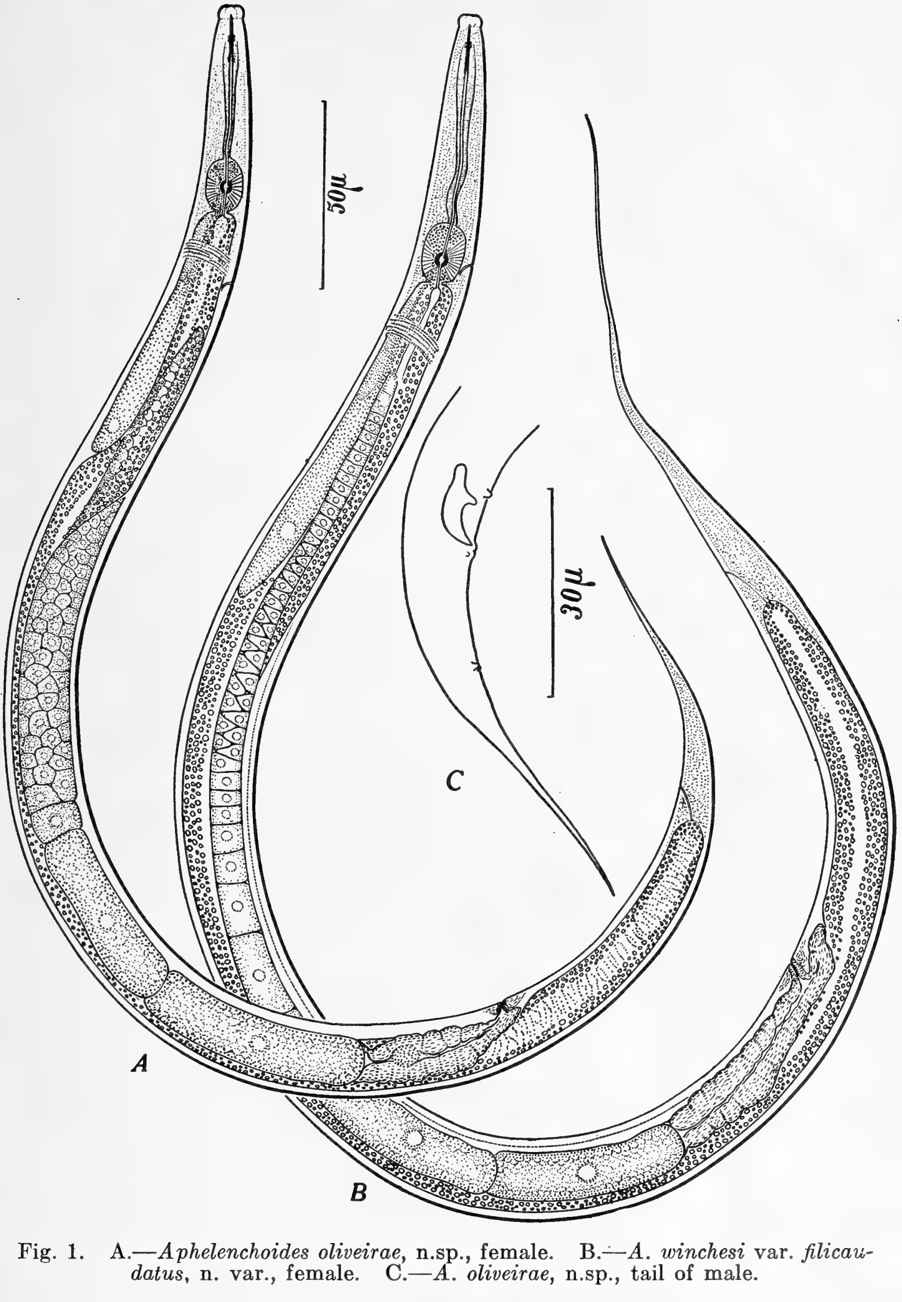

Fig. 1. A.—*Aphelenchoides oliveirae,* n.sp., female. B.—*A. winchesi* var. *filicaudatus,* n. var., female. C.—*A. oliveirae,* n.sp., tail of male.

datus. In fact the tail of the female of *A. elmiraensis* approaches in length that of *A. longicaudatus* being about 1½ times as great as the distance from vulva to anus. Van der Linde was probably justified in regarding *A. elmiraensis* as a distinct species but as other populations become known its differentiation may become increasingly difficult. That, of course, is equally true of some of the species described in the present paper.

Aphelenchoides linfordi, n. sp.

Measurements.—♁: Length, 500 to 600μ; width, 20 to 23μ; length of esophagus, 61 to 66μ; length of tail, 52 to 64μ; α, 24 to 27; β, 8 to 9.3; γ, 8.3 to 10.9; V, 71 to 75%.

Description.—Male unknown. Female (Fig. 3,B) with conspicuous, transverse cuticular striae forming distinct annules as much as 2μ wide near middle of body. Head region moderately well set off. Stylet 16 to 17μ long, without basal knobs. Excretory pore posterior to base of esophagus a distance equal to, or slightly less than, the corresponding body diameter. Tail tapers more or less evenly and ends in a moderately slender terminal portion, cuticular striae conspicuous for entire length. Postvulvar uterine sac short but usually rather wide. Ovary outstretched and extending to or slightly passing posterior end of esophageal glands. Eggs 62 to 68μ by 21 to 22μ.

Habitat.—Soil.

Locality.—Island of Oahu, Territory of Hawaii, U.S.A.

Comparisons and affinities.—That *Aphelenchoides linfordi* belongs to this group of "long tailed" *Aphelenchoides* is evidenced by its predacious habit and by its large and conspicuous esophageal glands. It differs from all other species of the group in having moderately coarse and conspicuous transverse striae. In addition females are somewhat shorter than those of any other related species and the width is relatively greater (α, 24 to 27) than in females of any other species except *A. oliveirae* (α, 25 to 32).

Aphelenchoides oliveirae, n. sp.

Measurements.—♂: Length, 384 to 484μ; width, 13 to 17μ; length of esophagus, 57 to 64μ; length of tail, 54 to 61μ; α, 28 to 32; β, 6.7 to 7.9; γ, 7 to 8.6. ♀: Length, 600 to 720μ; width, 20 to 27μ; length of esophagus, 60 to 67μ; length of tail, 82 to 94μ; α, 25 to 32; β, 9.2 to 11; γ, 6.7 to 8.5; V, 69 to 73%.

Description.—Cuticular striae fine, moderately inconspicuous. Head region (Fig. 1,A) comparatively short, only faintly set off. Stylet 14 to 15μ long in males, 15 to 16μ long in females, with small but distinct basal knobs. Excretory pore posterior to base of esophagus a distance equal to, or slightly less than, the corresponding body diameter. Tail of female tapers more or less evenly and ends in a slender terminal portion. Intestinal lumen between vulva and anus frequently wide and filled with fecal material. Anus very minute, indistinguishable in many specimens. Ovary outstretched, frequently extending nearly to nerve ring; posterior part wide showing several oöcytes in a given cross section. Postvulvar uterine sac virtually absent. Eggs 70 to 83μ by 18 to 19μ (based on eggs in relatively advanced stages of development). Tail of male (Fig. 1,C) similar in shape to that of female. Two pairs of papillae present, one pair about 8μ in front of anus and one pair about 18μ posterior to anus; a pair of adanal papillae probably present. Spicule about 14μ long and shaped as shown in Figure 1,C.

Habitat.—Soil.

Locality.—Island of Maui, Territory of Hawaii, U.S.A.

Comparisons and affinities.—This species differs from *A. demani* in having a shorter tail in both sexes. In his original description of *A. demani* Goodey

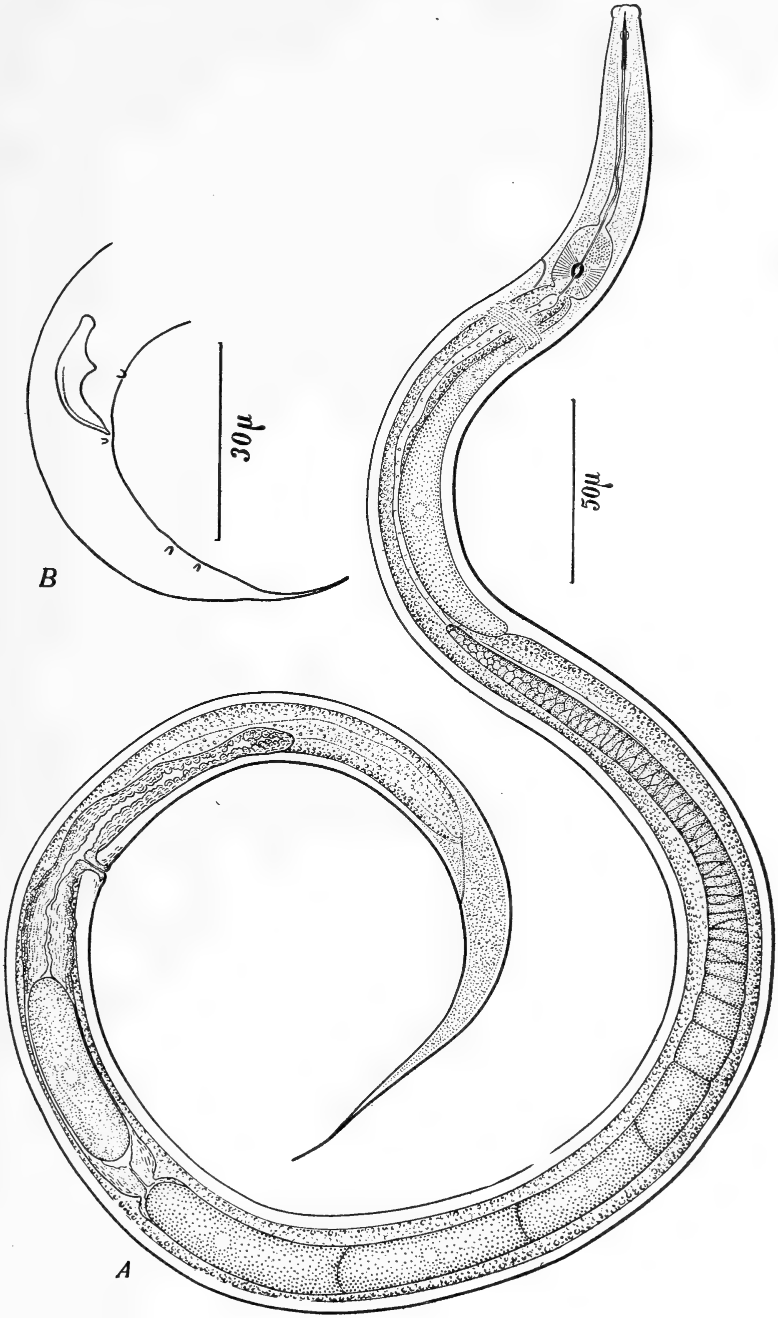

Fig. 2. A.—*Aphelenchoides tenuicaudatus*, female.
B.—*A. tenuicaudatus*, tail of male.

writes of the vagina as having stout walls while in the present species the vagina is relatively small and inconspicuous. The exceptionally wide ovary showing, toward its posterior end, several oöcytes in a cross section, may prove to be another, and a more important, difference. The posterior half of the male tail does not seem to be quite so clearly differentiated as in that of *A. demani* but the arrangement of the papillae in the two species seems to be identical.

Aphelenchoides oahuënsis, n. sp.

Measurements.—♀: Length, 760 to 860μ; width, 20 to 22μ; length of esophagus, 67 to 76μ; length of tail, 55 to 66μ; α, 35 to 40; β, 9.6 to 11.9; γ, 13 to 15; V, 69 to 75%.

Description.—Male unknown. Female (Fig. 3,B) with cuticular striae fine, moderately obscure. Head set off about as in *A. parietinus*. Stylet 14 to 15μ long with small but distinct basal knobs. Excretory pore inconspicuous, situated posterior to base of esophagus a distance about equal to corresponding body diameter. Tail tapers more or less evenly and ends in a slender terminal portion usually somewhat constricted near middle region. Postvulvar uterine sac usually extending about one-third distance from vulva to anus. Ovary outstretched, frequently extending nearly to nerve ring. Anus small and inconspicuous.

Habitat.—Soil.

Locality.—Island of Oahu, Territory of Hawaii, U.S.A.

Comparisons and affinities.—This species very closely resembles both *A. demani* and *A. oliveirae*. The female differs from that of *A. demani* in possessing a short postvulvar uterine sac and a shorter tail that is slightly constricted. It differs from *A. oliveirae* in having a postvulvar uterine sac, a narrower ovary, a longer and thinner walled uterus and a slightly constricted tail. Although probably not a point of taxonomic significance it may be noted that males were not present on the cultures of this species whereby it differs from the two other closely related species. The writer gave careful consideration to the advisability of regarding both the present species and *A. oliveirae* as varieties of *A. demani*. He finally decided that *A. oliveirae* and *A. oahuënsis* should be regarded as distinct species, the decision being influenced largely by differences in the female reproductive organs. If this is true, both forms obviously cannot be varieties of *A. demani* and the question arose as to which, if either, should be so regarded. In view of his inability to satisfactorily answer this question the writer decided, somewhat reluctantly, to regard each as a distinct species.

Apparently *Aphelenchoides* is a genus in which a great many of the populations that come to ones attention differ in some minor particular from those previously studied. This is certainly true for what now passes as *A. parietinus* and likewise it appears to be true for this group of "long-tailed," predaceous forms. What the confines of the species should be is a question for which only time and experience will provide an answer. It appears, however, that in many cases specific diagnoses must be sufficiently elastic to permit considerable variation or we will soon find ourselves with a vast number of species differentiated by minor and exceedingly variable characters.

As males are known for only part of the species the following key is based on the females. Information regarding the male tail is supplementary and is included for convenience in the hope that it may, at times, prove useful.

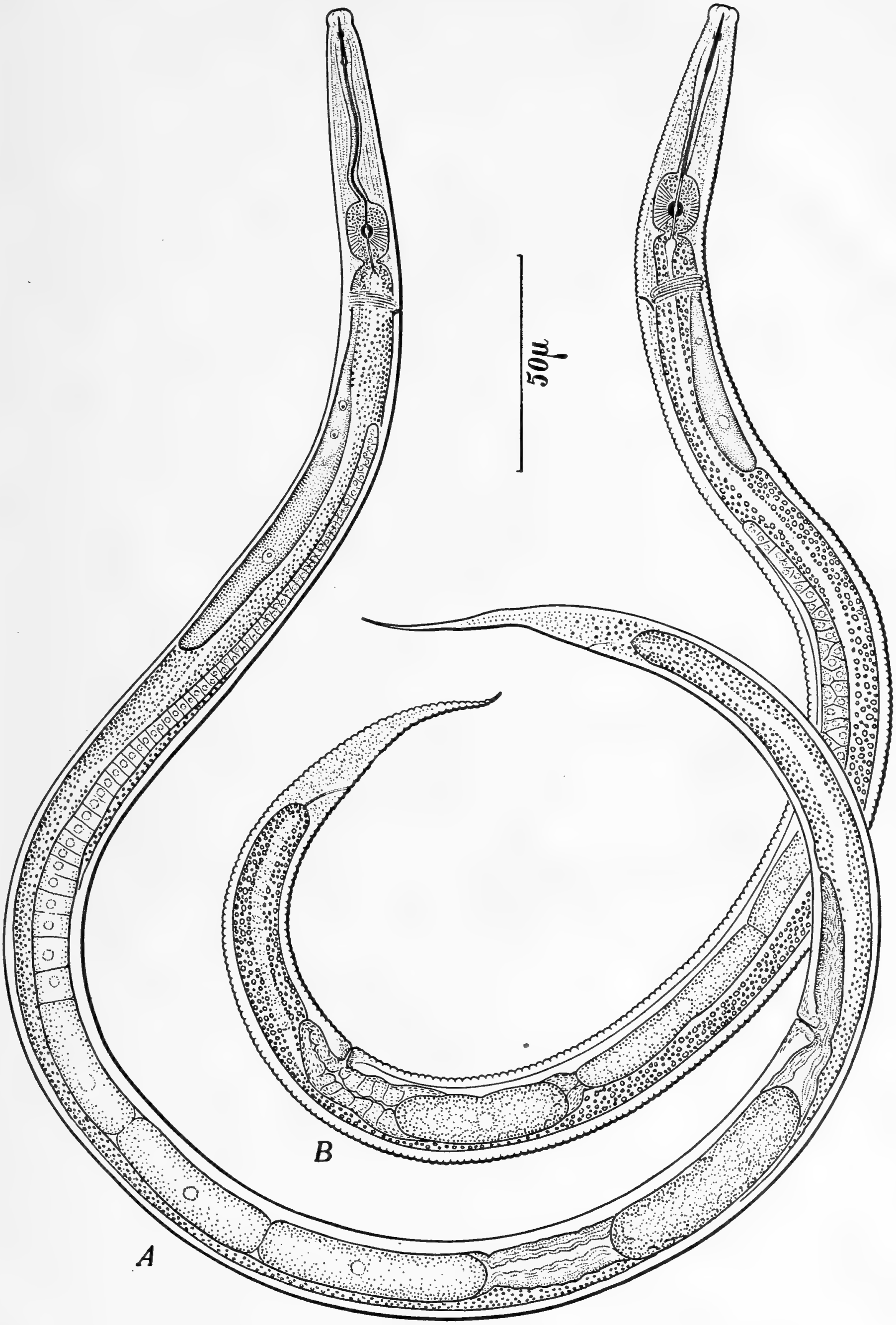

Fig. 3. A.—*Aphelenchoides oahuënsis*, n. sp. female.
B.—*A. linfordi*, n. sp., female.

The separation of *A. longicaudatus* obviously is unsatisfactory as the relative length of the female tail is subject to considerable variation. Cobb's description does not give precise information regarding the anatomical features upon which the key is primarily based and the long tail of the female seems to be the only character that can serve to differentiate this species.

KEY TO SPECIES OF "LONG-TAILED" APHELENCHOIDES DISCUSSED IN THIS PAPER

1. Length of tail in female at least twice as great as distance from vulva to anus..*longicaudatus*
   Length of tail in female not over one and one-half times as great as distance from vulva to anus..2
2. Stylet with small but distinct basal swellings or knobs........................3
   Stylet without basal swellings or knobs..5
3. Postvulvar uterine sac well developed often extending nearly one-third distance from vulva to anus; male unknown............*oahuënsis*
   Postvulvar uterine sac, if present, very short; both sexes usually encountered; male tail with one pair preanal, one pair indistinct adanal and one pair postanal papillae................................4
4. Vagina with stout walls and presumably moderately large and conspicuous; excretory pore a short distance behind bulb but in front of nerve ring; γ, in female, usually 5.3 to 6.5; posterior half of male tale set off..*demani*
   Vagina small and inconspicuous; excretory pore opposite or slightly behind nerve ring; γ, in female, 6.7 to 8.5; posterior half of male tail only faintly set off....................................*oliveirae*
5. Body of female with conspicuous and moderately coarse transverse striae forming distinct annules; male unknown................*linfordi*
   Body of female with inconspicuous transverse striae................6
6. Postvulvar uterine sac absent or very short; male tail with one pair of indistinct adanal and one pair of postanal papillae........*winchesi*
   Postvulvar uterine sac well developed usually extending at least half way from vulva to anus..7
7. Stylet short, about 10μ long; vulva relatively far anteriad, at about 62%; tail exceptionally long and slender, γ, in female, about 4.5; male tail with one pair of preanal, one pair of adanal and two pairs of postanal papillae................................*elmiraensis*
   Stylet 14μ long or longer; vulva at 66% or more; γ, in female, 7 or more 8
8. Lips faintly developed; tail of female relatively short, γ, about 12; male unknown..*oswegoensis*
   Lips well developed; tail of female slender and attenuated, γ, 7.7 to 11; male with one pair preanal, one pair indistinct adanal and two pairs of postanal papillae........................*tenuicaudatus*

MALACOLOGY.—*A new* Nenia *from Haiti and some notes on this genus.*[1] HARALD A. REHDER, U. S. National Museum. (Communicated by PAUL BARTSCH.)

Since 1786, when *Nenia tridens* Schweigger was first figured and described, albeit rather inadequately, no other member of this genus has turned up from the West Indian region. The discovery, therefore, of a species of *Nenia* from the southern peninsula of Haiti is a matter of considerable interest. The characters of this form are such that it can not be placed in any of the groups hitherto erected within the subfamily Neniinae, and I am therefore forming a new subgenus of *Nenia* for its reception, which I shall call:

Nenisca, n. subgen.

Shell of medium size, entire, fusiform, with fine, crowded, axial wrinkles which are irregular and anastomosing. Aperture large, dark inside, with a broadly expanded peristome. Superior lamella not continuous with the spiral lamella but widely discontinuous, the spiral lamella revolving peripherad of the superior lamella, its anterior end curving strongly towards the superior lamella, which continues for some distance beyond it. Lunella absent.

Type.—*Nenia* (*Nenisca*) *bartschi*, new species.

In the relation of the spiral and superior lamellae, this group approaches *Steeriana* Jousseaume, from which it differs greatly in external appearance. Its anastomosing sculpture is quite distinct.

Nenia (Nenisca) bartschi, n. sp. Figs. 1–5

Shell of medium size, rather solid, fusiform, with an entire and attenuate apex. Nuclear whorls 2, light red-brown in color, the first 1¾ whorls smooth, the last ¼ with rude axial riblets. The 6 postnuclear whorls are chestnut-brown in color, becoming deep purplish brown behind the aperture, and are marked by irregular, axial yellowish-ivory-white flammulate patches, which coalesce towards the top of each whorl; a row of small spots of chestnut brown, the ground color, is present just below the suture. The sculpture consists of fine, crowded, irregular, axial riblets, which anastomose and divaricate. The last whorl is the broadest, the penultimate whorl only slightly less in diameter; the whorls moderately convex, with an impressed suture. The aperture is rather large, ovate, dark chestnut-brown within, surrounded by a broad, expanded white peristome.

Superior lamella strong, convex on the left side, the lower end of the spiral lamella peripherad of and curving toward the former, the lamellae overlapping for about 1.5 mm. The inferior lamella stout, the free edge thickened, continuing as a low lamella on the axis for about one whorl. The principal palatal fold begins about 1.5 mm in from the peristome on the left side, and runs parallel with the suture for about 6 mm on the dorsal side. A lunella is absent. The subcolumellar lamella is typical, ascending, about 3.5 mm long. The clausilium has a rather long pedicle, and an elongate spatula, the distal end of which is bluntly pointed.

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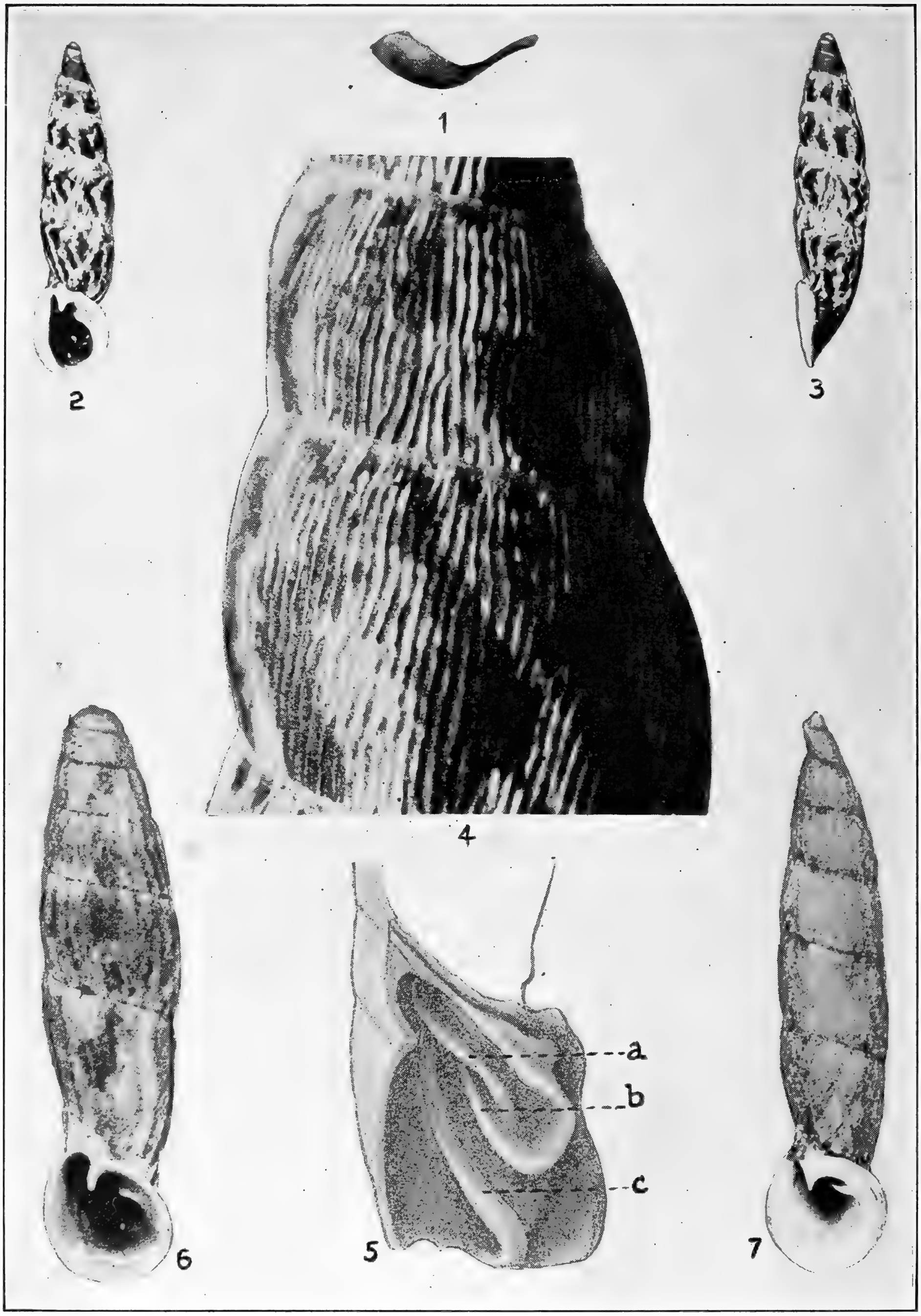

Figs. 1–5.—*Nenia* (*Nenisca*) *bartschi,* n. sp. 1, Clausilium. 2–3, Shell ×2. 4, Detail of sculpture ×15. 5, Detail showing lamellae: *a,* spiral lamella; *b,* superior lamella; *c,* inferior lamella. Fig. 6.—*Nenia* (*Paranenia*) *perarata* v. Martens. Shell ×3. Fig. 7.—*Nenia* (*Nenia*) *tridens* Schweigger. Shell ×3.

The type, U.S.N.M. Cat. No. 380074, was collected by William J. Eyerdam at 1,000 meters altitude on the top of Mt. Rochelle (or Rochelois), south of Rochelois, Dept. du Sud, Haiti. It has 8 whorls and measures: Length 22.6 mm; diameter 5 mm; height of aperture 6.3 mm, width of aperture 4.9 mm.

Four other specimens, U.S.N.M. Cat. No. 499244, come from the same lot.

Two bleached specimens and a few fragments, U.S.N.M. Cat. No. 403023, of what appears to be this species were collected by Charles R. Orcutt on the estate of the Haitian American Sugar Company, just north of Port-au-Prince, where they were probably washed down from the mountains southeast of the city.

I dedicate this interesting species to Dr. Paul Bartsch, who through his cruises throughout the West Indies, and consequent systematic studies, has done much to elucidate the terrestrial malacological fauna of the Antillean region.

The only other West Indian *Nenia* is, as is well known, the Puerto Rican *Nenia tridens* Schweigger, the sole representative of the typical subgenus *Nenia.* This group is distinguished by its lack of a lunella, by the thickened peristome and by the peculiar sculpture and apical character; the embryonic shell, generally lost, is slender and set at an angle on the succeeding whorl. (fig. 7).

Paranenia, n. subgen.

Shell rather stout, with an entire blunt, rounded apex. Sculpture consisting of strong, oblique, broad, rounded, moderately distant ribs, crossed obliquely by fine growth lines. A lunella is present.

Type.—Nenia perarata von Martens.

Nenia perarata von Martens (fig. 6) from Colombia has been placed in *Nenia* on account of its rather similar sculpture, but it does not have the narrower, decollate apex of *Nenia tridens* Schweigger, and it possesses a lunella. These important differences, as well as its quite distinct geographic range, merit its being placed in a separate subgenus.

MALACOLOGY.—*A new intermediate host of the Asiatic blood fluke,* Schistosoma japonicum *Katsurata.*[1] PAUL BARTSCH, U. S. National Museum.

Dr. Y. T. Yao has sent to the United States National Museum a large series of *Oncomelania* for determination, which he collected at Wang Ling Hsiang, Pingyang Hsien, in the central part of Kwangsi Province, China, which he found served as intermediate hosts of the Asiatic Blood Fluke in that region. These proved to be an undescribed species of *Oncomelania,* which I take pleasure in naming for its discoverer.

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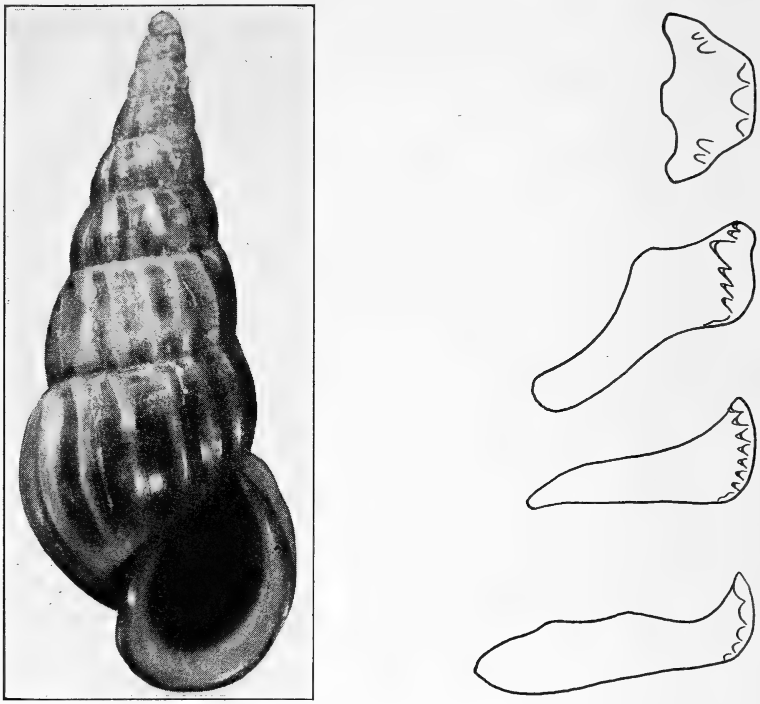
This find extends the range of the genus *Oncomelania* considerably farther south than heretofore known.



Figs. 1–2.—*Oncomelania yaoi*, n. sp. 1, shell, ×10. 2. radula.

Oncomelania yaoi n. sp.

Shell elongate-conic; early whorls pinkish, the rest wax yellow, translucent, shining, with the edge of the peristome tinged with a dusky suffusion. Nuclear whorls 2, well rounded smooth, excepting microscopic granulations. Postnuclear whorls slightly rounded, almost flattened; the first smooth, the second showing in its distal part the beginning of axial ribs, which on the succeeding turns become very strongly developed. These ribs are rather distantly spaced, i.e., they are about one-half as wide at their base as the spaces that separate them. Of these ribs 15 are present on all the turns but the last, which has 12. On the last whorl there is a very heavy varix a little distance behind the peristome. The axial ribs and intercostal spaces are marked by fine wavy hairlike incremental lines. Suture well impressed. Periphery well rounded. Base short, well rounded, marked by the continuation of the sculpture of the spire, but here the axial ribs become enfeebled and evanesce as they pass into the narrow umbilicus. Aperture ovate, somewhat oblique and effuse, and expanded at the junction of the basal and columellar angle, appressed to the preceding turn at the parietal wall. Operculum thin, corneous paucispiral, having 2.2 whorls and an excentric nucleus. The radula has the formula: $\frac{1\text{–}1\text{–}1}{2\text{–}2}$, 2:1:3, 8, 5.

The type, U.S.N.M. no. 469149, has 9.2 whorls and measures: Length, 8.8 mm; greater diameter, 3.8 mm; lesser diameter, 3.3 mm. The rest bear the number 469150.

Its almost flattened whorls, brilliant translucent wax color with pinkish early whorls, heavy distantly spaced, axial, ribs and peculiar radula formula easily distinguish it from all the known species of *Oncomelania.*

MAMMALOGY.—*Two new pocket gophers of the genus* Heterogeomys *from Mexico.*[1] E. A. Goldman, Bureau of Biological Survey.

In connection with a group alignment of the forms of the genus *Heterogeomys* by E. W. Nelson and the writer four new subspecies were described (Proc. Biol. Soc. Washington, vol. 42, pp. 147–152, March 30, 1929). A more critical examination and further consideration of material available have resulted in the segregation of two additional forms, as follows:

Heterogeomys hispidus tehuantepecus, subsp. nov.

Tehuantepec Pocket Gopher

Type.—From mountains 12 miles northwest of Santo Domingo and about 60 miles north of Tehuantepec City, Oaxaca, Mexico (altitude 1,600 feet). No. 73434, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection); collected by Nelson and Goldman, June 18, 1895. Original number 8092.

Distribution.—Known only from the type locality in the mountains near the top of the continental divide on the southern side of the Isthmus of Tehuantepec.

General characters.—Most closely resembling *Heterogeomys hispidus hispidus* from near Jalapa, Vera Cruz; size similar, but color lighter, near "mars brown" instead of "seal brown" (Ridgway, 1912); differing also in cranial details, including more highly arched rostrum. Similar in general to *Heterogeomys hispidus isthmicus* of Gulf coast plain on northern side of Isthmus of Tehuantepec, but color somewhat darker, near "mars brown" instead of "chestnut brown"; skull differing most notably in less deeply sinuous lambdoid crest. Similar in general size to *Heterogeomys hispidus chiapensis* of high mountains of central Chiapas, but color light, near "mars brown" instead of "seal brown"; pelage coarser and thinner; skull heavier and quite different in detail.

Color.—*Type* (acquiring fresh pelage): Head and anterior upper parts "mars brown" in fresh pelage, becoming "chestnut brown" in worn pelage on posterior part of back,flanks, and limbs; under parts thinly haired, "cinnamon brown"; feet scantily covered with brownish hairs; tail nearly naked near base, becoming entirely bare near tip, the dried skin dark brown.

Skull.—Most closely resembling that of *hispidus*, but nasals more highly arched, less flattened posteriorly; frontal region less depressed anteriorly; jugal narrower, more evenly rounded anteriorly at union with maxilla; auditory bullae less inflated, not usually projecting below plane of lower

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[1] Received January 27, 1939.

surface of basioccipital (usually projecting below this plane in *hispidus*); molariform toothrows shorter. Very similar in general form to that of *isthmicus*, but lambdoid crest much less deeply sinuous, a slight concavity representing the abrupt crescentic median deflection forward present in *isthmicus* as viewed from above; nasals less flattened, rising more prominently above level of premaxillae; maxillary arm of zygoma lighter, encroaching less deeply on premaxillae which are correspondingly broader posteriorly; dentition about the same. Compared with that of *chiapensis* the skull is similar in general size, but heavier in structure; rostrum broader; interorbital region narrower, the frontal surface less even, more concave near median line and rising higher anteriorly; maxillary arm of zygoma encroaching farther on premaxillae which are correspondingly reduced in width posteriorly; auditory bullae larger; palatopterygoids broader; dentition heavier.

Measurements.—*Type:* Total length, 332 mm; tail, 102; hind foot, 48. Two adult female topotypes, respectively: 348, 306; 94, 81; 51, 41. *Skull* (type [♂] and an adult female topotype, respectively): Occipitonasal length, 61.7, 61.4; zygomatic breadth, 39.2, 40.8; breadth across squamosals (over mastoids), 38.2, 39.6; interorbital constriction, 10.7, 10.8; length of nasals, 23.9, 24.2; maxillary toothrow (alveoli), 13, 13.3; width of upper incisors (cutting edge), 8.5, 8.7.

Remarks.—The resemblance of *tehuantepecus* to typical *hispidus* suggests that there may be some connection between the two through the mountains of the interior, but intergradation is also probable with the near geographic neighbor *isthmicus* of the Gulf coastal plains. In the genus *Heterogeomys*, as in other pocket gophers, the males are usually larger than the females, but in the present form an adult female slightly exceeds the type, a male of about the same age.

Specimens examined.—Eight, all from the type locality.

Heterogeomys hispidus teapensis, subsp. nov.

Tabasco Pocket Gopher

Type.—From Teapa, Tabasco, Mexico. No. 100035, ♀ adult, skin and skull, U. S. National Museum (Biological Survey collection); collected by Nelson and Goldman, March 23, 1900. Original number 14056.

Distribution.—Lowlands and lower mountain slopes in southern Tabasco.

General characters.—A large subspecies, similar to *Heterogeomys hispidus chiapensis* of high mountains of central Chiapas, but color light, near "mars brown" instead of "seal brown"; pelage coarser and thinner; skull more elongated. Similar to *Heterogeomys hispidus isthmicus* of coastal plain in Vera Cruz on north side of Isthmus of Tehuantepec, but color somewhat darker, the upper parts near "mars brown" instead of "chestnut brown"; skull longer, with lambdoid crest less deeply sinuous. Somewhat like *Heterogeomys hispidus yucatenensis* of the Yucatan peninsula, but larger and slightly darker; skull with more elongated rostrum.

Color.—*Type* (acquiring fresh pelage): Upper parts in general near "mars brown"; under parts and limbs nearly naked, the scattered hairs light brownish; tail bare, the dried skin brownish.

Skull.—Similar to that of *chiapensis* but longer, with narrower zygomata; rostrum and nasals longer; dentition heavier, the incisors decidedly broader.

Differing from that of *yucatenensis* in decidedly larger size, greater elongation of rostrum, and much heavier dentition. Compared with that of *isthmicus* the skull is longer, the lengthening mainly in rostrum; zygomata actually as well as relatively narrower; nasals longer; lambdoid crest less deeply sinuous; dentition similar.

Measurements.—*Type*: Total length, 338 mm; tail, 91; hind foot, 48.5. An adult female topotype: 334; 90; 46. *Skull* (type [♀] and an adult female topotype, respectively): Occipitonasasl length, 61.3, 59; zygomatic breadth, 36, 37; breadth across squamosals (over mastoids), 36.3, 36; interorbital constriction, 10.3, 10.8; length of nasals, 24.8, 24; maxillary toothrow (alveoli), 15, 13.4; width of upper incisors (cutting edge), 8.5, 8.3.

Remarks.—Specimens from low elevations in Tabasco were referred by Nelson and the writer (Proc. Biol. Soc. Washington, vol. 42, p. 152, March 30, 1929) to *chiapensis* of the high mountains of central Chiapas, although some differences were pointed out. More critical examination seems to warrant their segregation as a geographic race.

Specimens examined.—Total number, five, all from Tabasco, as follows: Montecristo, 2; Teapa (type locality), 3.

ORNITHOLOGY.—*Two new races of birds from the Indo-Chinese sub-region.*[1] H. G. DEIGNAN, U. S. National Museum. (Communicated by H. FRIEDMANN.)

A recent visit by the writer to the American Museum of Natural History and the Academy of Natural Sciences of Philadelphia has shown that two more Siamese birds must be granted subspecific recognition. For the loan of their material, thanks are hereby expressed to the authorities of the institutions named.

Cyanops incognita euroa, subsp. nov.

Type.—Adult male, U. S. National Museum no. 337073; collected at Khao Sa-bap, Chantabun province, S.E. Siam, 28 April, 1937, by H. G. Deignan.

Subspecific characters.—Adults of the new form are readily distinguishable from adults of typical *incognita* (Tenasserim) by the greater size of the red patch on the hind-crown (covering at least twice as large an area as in *incognita*), and by the paler turquoise-blue of the throat. Seventeen adults of *euroa* have been compared with four adults of *incognita.*

Range.—South-eastern Siam, Cambodia, Laos, and Tongking.

Napothera crispifrons calcicola, subsp. nov.

Type.—Adult male, U. S. National Museum no. 332024; collected at Hin Lap, East Siam, 8 December, 1931, by Dr. Hugh M. Smith.

Subspecific characters.—From *N. cr. annamensis,* distinguished at once by complete absence of slaty color, above and below. From typical *crispifrons,* it may be known by its having the broad shaft-streaks of the throat

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black instead of dark brown, affording a stronger contrast with the white portion of the feathers; by having a distinct rufous area on each side of the neck between the white throat and the rufous-washed ear-coverts; by having the dark edgings of the feathers of crown and mantle obsolete, giving the upperparts a more uniform aspect and causing the gray shafts to stand out more boldly. Three specimens of *calcicola* have been compared with four specimens of *annamensis* and seven specimens of *crispifrons*.

Range.—Eastern Siam.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

41ST ANNUAL MEETING

The 41st Annual Meeting of the Washington Academy of Sciences was held in the Assembly Hall of the Cosmos Club, January 19, 1939, with 55 members present. President PAUL HOWE called the meeting to order at 9.20 P.M.

The minutes of the 40th Annual Meeting were presented as published in the Journal and were approved as published.

The Corresponding Secretary, NATHAN R. SMITH, submitted the following report on the membership and activities of the Academy:

Membership: during 1938, 41 were elected to resident and 1 to non-resident active membership. Of these, 40 have qualified for resident membership. The non-resident member was recently elected and has not replied to date. Five were elected in recognition of their work in Chemistry, and also five in Botany; four each in Engineering, Protozoology, and Biology; three each in Physics, Medicine, Forestry, and Mycology; two in Anthropology; and one each in Geology, Bacteriology, Genetics, and Soil Science. There were two resignations (1 resident and 1 non-resident) and ten deaths (7 resident and 3 non-resident). Seven were transferred from resident to non-resident and one from non-resident to resident membership. Six resident and one non-resident member retired from professional work during the year and were retained as active members without the payment of dues.

On January 1, 1939, the membership, therefore, consisted of 11 Honorary Members, 3 Patrons, and 554 Active Members, of which 2 are Life Members. Of the 554 active members, 33 do not pay dues because of retirement from professional work (27 resident and 6 non-resident). There are, therefore, 521 active members who should pay dues, 391 resident and 130 non-resident. Since the number of resident active members is limited to 400 and the non-resident to 200, there were 9 vacancies in the resident and 70 vacancies in the non-resident active membership. The status of the resident active membership as regards number is very satisfactory owing to the efficiency of the Membership Committee. The non-resident class is still very unsatisfactory, although slightly better than last year.

The deaths of the following members are reported at this time:

GEORGE BIRD GRINNELL, non-resident, April 11, 1938.
MAURICE C. HALL, resident, May 1, 1938.
FREDERICK I. ALLEN, non-resident, May 17, 1938.
TRUMAN MICHELSON, resident, July 26, 1938.
EARL B. MCKINLEY, resident, July 29, 1938.

Guy N. Collins, resident, August 14, 1938.
Victor K. Chesnut, resident, August 29, 1938.
Willis R. Gregg, resident, September 14, 1938.
Giuseppi Stefanini, honorary, September 15, 1938.
Charles E. Monroe, honorary, December 7, 1938.

The Board of Managers held seven meetings during the year with an average attendance of 17. Two special committees were appointed, one on the format of the Journal and the other on the Financial Status of the Journal. The report of each committee has been accepted by the Board. Dr. A. L. Day was appointed a delegate to the dedication of the Franklin Institute as a Memorial to Benjamin Franklin. The Institute awarded a Certificate of Appreciation to the Academy for this action.

On motion it was voted to accept the Corresponding Secretary's report and to place it on file.

The Recording Secretary presented the following report:

The 41st year of the Academy began with the 284th meeting and ended tonight with the 289th meeting.

The 284th meeting was held in the Assembly Hall of the Cosmos Club on February 17, 1938. The address was given by Charles Thom, the retiring President of the Academy, on the subject *A Microbiologist Digs in the Soil.* Attendance about 75.

The 285th meeting was held in the Assembly Hall of the Cosmos Club on March 17, 1938. The address was given by A. K. Balls of the Bureau of Chemistry and Soils on the subject *Some Modern Aspects of Enzyme Catalysis.* Attendance about 70.

The 286th meeting was held in the Auditorium of the National Museum on April 21, 1938. The address of the evening was given by Marius Barbeau, the Dominion Ethnologist of Canada, on the subject *How Totem Poles Originated.* The address was illustrated by motion pictures, slides and by Indian songs with drums. Attendance about 125.

The 287th meeting was held in the Assembly Hall of the Cosmos Club on November 17, 1938. The address on the subject *Cancer and Cooperative Research* was given by R. R. Spencer, National Cancer Institute of the National Institute of Health. Attendance about 50.

The 288th meeting was held in the Assembly Hall of the Cosmos Club on December 15, 1938. An illustrated address was given by F. H. H. Roberts, Jr., on the subject *The Folsom Problem in American Archeology.* Attendance about 55.

The 289th meeting of the Academy was held on January 19, 1939, in the Assembly Hall of the Cosmos Club with 85 persons present. The address of the evening was given by Paul E. Howe, the retiring President of the Academy on the subject *Some Problems in Attaining Adequate Nutrition.* This was the final meeting of the 41st year of the Academy.

On motion it was voted to accept the Recording Secretary's report and to place it on file.

The report of the Treasurer, H. G. Avers, was read by Howard S. Rappleye:

CASH RECEIPTS AND DISBURSEMENTS

RECEIPTS

From Back dues	$ 110.00
From Dues for 1938	2,425.10
From Dues for 1939	30.00

From Life Membership (L. H. James)	72.24	
From Subscriptions for 1938	836.40	
From Subscriptions for 1939	337.80	
From Sales of Journals	167.34	
From Payments for reprints	172.54	
From Sales of 1937 Directory	2.80	
From Interest on Deposits	55.45	
From Interest on Investments	1,085.10	
Total receipts	5,294.77	
Cash Balance January 1, 1938	8,807.11	
To be accounted for		$14,101.88

DISBURSEMENTS

For Secretary's Office, 1937		$ 97.85	
For Secretary's Office, 1938		171.90	
For Treasurer's Office		202.52	
For Journal Printing, 1937		276.82	
For Journal Printing, 1938		2,455.92	
For Journal Reprints, 1937		56.26	
For Journal Reprints, 1938		355.71	
For Journal Office, 1937		50.65	
For Journal Office, 1938		9.60	
For Journal Illustrations		281.57	
For Meetings Committee, 1937		58.35	
For Meetings Committee, 1938		223.60	
For Membership Committee, 1937		4.00	
For Dues of Retired Member returned		5.00	
Bank Debit Memos, as follows:—			
Reprints	$12.61		
Dues	10.35		
Subscription	.11	23.07	
Deposited in Savings Account		8,314.12	
Total disbursements		12,586.94	
Cash Balance December 31, 1938		1,514.94	
Total			$14,101.88

RECONCILIATION OF BANK BALANCE

Balance as per Cash Book, December 31, 1938			$ 1,514.94
Bank Balance, American Security & Trust Co. as per statement of December 31, 1938		$ 1,696.44	
Checks outstanding, not cashed:			
No. 170	$ 21.50		
No. 503	160.00		
Total		181.50	
Balance			$ 1,514.94

Check No. 170 listed as outstanding, was issued in May, 1934, but has not been cashed.

INVESTMENTS

409 Shares stock of Washington Sanitary Improvement Co., par value $10 per share, cost	$ 4,090.00
20 Shares stock Potomac Electric Power Co., 6% Pref.; cost	2,247.50
1 Bond of Interborough Rapid Transit Co. No. 37020, interest at 5%; due Jan. 1966; par value $1000; cost	995.00
*1 Bond of Chicago Railways Co. No. 1027; interest at 5%; due 1927; par value $1000 less $250; cost	713.87
1 Real Estate note of T. Q. Donaldson (No. 6 of 12) dated June 26, 1937 for 3 years; interest at 5%; cost	1,000.00
2 Real estate notes of Yetta Korman et als., dated Oct. 5, 1938 for 3 years; (No. 7 of 37 for $500, and No. 8 of 37 for $500); interest at 5%; cost	1,000.00
3 Real estate notes of Ell & Kay Bldg. & Investment Co. dated Oct. 15, 1938 for 3 years; (No. 75 of 165 for $2000, No. 83 of 165 for $1000, and No. 101 of 165 for $1000); interest at 5%; cost	4,000.00
Butler notes—Property at 1707 L St., N. W. bought in by note holders—Academy's share 4/250ths; Interest amounting to $20 received in 1938; cost	2,000.00
	$16,046.37
Deposited in Savings Account, American Security & Trust Co.	8,314.12
Total	$24,360.49
Bank Balance December 31, 1938	1,514.94
Total Assets	$25,875.43

ALLOTMENTS

	Allotted Receipts	*Expended*	
Secretary's Office	$ 450.00	$ 171.90	(1)
Treasurer's Office	225.00	202.52	(2)
Journal	2,400.00+$1,476.26=$3,876.26	3,102.80	(3)
Meetings Committee.	350.00	223.60	
Membership Committee	10.00	———	
Executive Committee.	10.00	———	

Bills outstanding, not paid, at end of year:

(1) Secretary's Office	$105.70
(2) Treasurer's Office	2.75
(3) Journal	379.55

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* The bond of the Chicago Railways Company was not paid upon maturity due to the expiration of franchise and failure of the Legislature to enact continuing legislation; interest has been paid to date under authority of the Courts, and $250 has been paid on the principal since maturity.

The Auditing Committee, W. A. Dayton, Albert R. Merz, and Paul A. Smith reported:

> We, the undersigned members of the committee appointed to audit the accounts of the Treasurer of the Washington Academy of Sciences for the year 1938, desire first to compliment Treasurer H. G. Avers on the

careful and orderly manner in which his records are kept, and to express our appreciation of the courtesy extended to us by Mr. AVERS and his assistant, Mr. MEADS. This had greatly facilitated the work of the auditing committee.

The Treasurer's records of receipts and expenditures, as shown in his account books and included in his report, have been carefully examined and found correct. All vouchers have been found to be correct and properly approved.

The balance sheets submitted by the bank and the securities listed in the Treasurer's report have been examined. The statement of the assets of the Academy was found correct.

No coupons not yet due were missing from any of the coupon-bearing securities.

It was moved to accept the reports of the Treasurer and the Auditing Committee and to place them on file. By vote it was so ordered.

The Board of Editors, EBEN H. TOOLE, FREDERICK D. ROSSINI and C. LEWIS GAZIN submitted the following report:

Volume 28 for 1938 has 556 pages, or 8 pages more than the preceding volume. This was an average of 46⅓ pages per number. Of the 72 original contributions, 10 were addresses before the Academy or affiliated societies and 2 were brief corrections of previous articles in the Journal. Forty papers discussed biological forms new to science. Of the original papers, 41 were by members of the Academy and 31 were by non-members. The papers were illustrated by 22 halftones, and 64 line cuts, occupying 58 pages. Obituaries appeared of 8 deceased members. In addition to the proceedings of the Academy, which occupied 7 pages, 4 affiliated societies published their proceedings in the Journal. The Philosophical Society furnished approximately 25 pages with abstracts of 37 papers presented before that society; the Chemical Society about 11 pages, with 17 abstracts; the Geological Society about 10 pages, with 14 abstracts; and the Botanical Society 5 pages, with 12 abstracts. All of the proceedings occupied somewhat more than one average sized number.

The total net cost to the Academy of issuing the Journal for 1938 was $3,319.08, compared with $3,216.46 for 1937. The cost of printing was $4.91 per page, which included $0.12 per page for alterations. The comparable cost per page for printing in 1937 was $4.81. The cost of engravings was approximately $5.54 per page of illustrations or $0.58 per page, based on number of pages in the volume. A portion of this cost was paid by authors. The total cost to the Academy of reprints furnished free to authors was $222.75.

The report of the Board of Editors was accepted and ordered placed on file.

The Tellers, S. F. BLAKE, N. R. ELLIS and H. S. ISBELL, reported the election of the following officers: President, CHARLES E. CHAMBLISS; Non-resident Vice Presidents, H. S. GRAVES and R. B. SOSMAN; Corresponding Secretary, NATHAN R. SMITH; Recording Secretary, OSCAR S. ADAMS; Treasurer, H. G. AVERS; Board of Managers (to serve 3 years) J. H. HIBBEN and G. STEINER; (to serve 2 years to fill a vacancy) H. C. FULLER.

The Corresponding Secretary read the list of nominations for Vice-Presidents submitted by the affiliated societies as follows:

Philosophical Society—F. G. BRICKWEDDE.
Anthropological Society—HENRY B. COLLINS, JR.
Biological Society—W. B. BELL.
Chemical Society—B. H. NICOLET.

Entomological Society—AUSTIN H. CLARK.
National Geographic Society—ALEXANDER WETMORE.
Geological Society—H. D. MISER.
Medical Society—FRED O. COE.
Historical Society—ALLEN C. CLARK.
Botanical Society—G. F. GRAVATT.
Archeological Society—ALES HRDLICKA.
Foresters—W. A. DAYTON.
Washington Society of Engineers—PAUL C. WHITNEY.
Electrical Engineers—H. L. CURTIS.
Mechanical Engineers—H. L. WHITTEMORE.
Helminthological Society—E. W. PRICE.
Bacteriological Society—L. A. ROGERS.
Military Engineers—WILLIAM BOWIE.
Radio Engineers—J. H. DELLINGER.

By vote of the Academy, the Recording Secretary was instructed to cast one ballot for the list as read. This was done and the Vice-Presidents were declared duly elected.

President Howe appointed Past Presidents WETMORE and TUCKERMAN to escort President-elect CHAMBLISS to the chair. President CHAMBLISS thanked the Academy for the honor conferred upon him and urged upon all to be mindful of their duty to the Academy.

Adjournment followed at 10 P.M.

OSCAR S. ADAMS, *Recording Secretary*

CHEMICAL SOCIETY

503RD MEETING

The 503rd meeting was held in the Auditorium of the Cosmos Club on Thursday, October 27, 1938, with President DRAKE in the chair. This was the first of the newly initiated informal meetings. The society was addressed as follows:

B. J. MAIR: *The chemical composition of the lubricant fraction of a midcontinent petroleum.*—The results of a joint investigation of the Bureau of Standards and the American Petroleum Institute on the chemical composition of the lubricant fraction of a midcontinent petroleum were reported. The lubricant fraction was separated into a "wax" portion, an "asphaltic" portion, an "extract" portion and a "water-white" oil portion. The water-white oil portion was first separated by distillation into substantially constant-boiling fractions. Charges of these fractions were prepared and each charge of about 500 g. separated by extraction with acetone in 14 m. columns into 25 to 35 fractions. A number of properties were determined on these fractions each of which represents 1/40,000 part of the original crude petroleum (Mair and Schicktanz, J. Research NBS **17**: 909, 1936). The data on these fractions was correlated with data available in the literature on synthetic hydrocarbons, and conclusions drawn as to their constitution (Mair and Willingham, J. Research NBS **17**: 923, 1936).

The extract portion was then investigated in an analogous manner by distillation followed by extraction of charges with narrow-boiling ranges, except that in this instance methyl cyanide was used as the solvent. A large number of physical properties were determined on these fractions (Mair and Willingham, J. Research NBS **21**: 535, 1938).

To obtain information as to the amount of aromatic hydrocarbons in these fractions, a selected 15 of them were completely hydrogenated, and the physical and chemical properties of the hydrogenated fractions determined (Mair, Willingham and Streiff, J. Research NBS **21**: 565, 1938). The sulfur, nitrogen, and oxygen were removed from the fractions, and the fractions were completely converted to naphthenes by the hydrogenation process. There was no change in the number of carbon atoms per molecule.

Finally a correlation was made (Mair, Willingham, and Streiff, J. Research NBS **21**: 581, 1938) of the data on the extract fractions, the hydrogenated fractions, the water-white oil fractions, and of the data available in the literature on synthetic hydrocarbons. The conclusions resulting from the correlation were that, excluding the "wax" and "asphaltic" portions, the oil contains: (1) about 60 per cent of naphthenes with from 1 to 3 naphthenic rings per molecule (a very small amount of material containing 4 naphthenic rings per molecule is probably present also); (2) about 15 per cent of material with 1 aromatic ring and with from 1 to 3 naphthenic rings per molecule, together with a small amount of sulfur and oxygen compounds; (3) about 14 per cent of material with 2 aromatic rings (linked through two common carbon atoms) and 2 naphthene rings per molecule, together with a small amount of sulfur and oxygen compounds; and (4) about 11 per cent of material with more than 2 aromatic rings per molecule (each probably linked through 2 common carbon atoms) and 1 or 2 naphthene rings per molecule, together with some sulfur, nitrogen, and oxygen compounds. (*Author's abstract.*)

504TH MEETING

The 504th meeting was held in the Auditorium of the Cosmos Club on Thursday, November 10, 1938, with President DRAKE presiding. The program was preceded by the annual election of officers for the ensuing year. The following were elected: *President:* FRANK C. KRACEK, Geophysical Laboratory; *Secretary:* RAYMOND M. HANN, National Institute of Health; *Treasurer:* NORMAN BEKKEDAHL, National Bureau of Standards; *Councilors:* N. L. DRAKE, H. T. HERRICK, J. H. HIBBEN, G. E. HILBERT, G. E. F. LUNDELL, B. H. NICOLET, B. D. VAN EVERA; *Board of Managers:* A. H. BLATT, P. H. GROGGINS, H. L. J. HALLER, F. D. ROSSINI, J. F. SCHAIRER, E. R. SMITH. The Society was then addressed as follows:

LOUIS F. FIESER, Harvard University: *Cancer producing hydrocarbons.*—During the eight years since the discovery that pure 1, 2, 5, 6-dibenzanthracene has the ability to produce malignant growths in test animals, particular attention among workers in the field has been given to the biological investigation of this hydrocarbon and of two other polynuclear aromatic hydrocarbons. 3, 4-Benzpyrene is of special interest because it produces tumors with great rapidity and because, as it is a constituent of carcinogenic tars, it undoubtedly has been responsible for the induction of skin cancer in humans. Of even more interest is the highly potent carcinogen methylcholanthrene, for this bears some structural relationship to sex hormones arising in the body as products of normal steroid metabolism, and it has been produced by the chemical degradation of two acids normally present in the bile, and also from cholesterol.

An analysis of the collected data from biological experiments conducted in numerous research centers reveals a number of points of interest concerning the actions of these three hydrocarbons. They all produce tumors with such uniform regularity, when tested under suitable conditions in non-resistant tissues, that the most significant criterion of relative potency is given by the average time required for the induction of tumors. The average induction time, for a given tissue, a given technique of administration, and a given dosage, is a reasonably reproducible and accurately determinable quantity. Consideration of pertinent data affords significant information on the influence of the nature, state, and dosage of the hydrocarbon administered, and on such variable factors associated with the nature of the test animal as the sex, age, strain, species, and tissue. With this information, it is possible to correlate a large body of data on a comparable basis and to arrive at critically weighted average values for the induction periods of the three hydrocarbons as tested in various tissues of rats and mice. It is concluded that all three compounds act somewhat more rapidly when injected subcutaneously into mice than when applied to the skin, and produce a more rapid response in the subcutaneous tissue of mice than of rats. Methylcholanthrene is perhaps slightly more potent than 3, 4-benzpyrene, and both substances act considerably more rapidly than 1, 2, 5, 6-dibenzanthracene.

In seeking to discover the structural features responsible for the marked cancer producing properties of methylcholanthrene, a number of simpler substances having various features of its structure have been synthesized and tested. The closest approach to a simpler model-compound has been found in 10-methyl-1,2-benzanthracene, and it has been concluded that the feature of structure of greatest importance in methylcholanthrene is the presence of a 1,2-benzanthracene ring system with an alkyl substituent at the meso position 10. Substitution in the alternate meso position 9 is also favorable for carcinogenic activity, but to a lesser extent, and there are definite indications of a reinforcing function of alkyl groups in a meso and an α-position in the anthracene nucleus. Studies of possible models of 3,4-benzpyrene have not progressed as far, but it appears at present that this hydrocarbon probably has a structure unique unto itself.

Relationships between structure and carcinogenic activity have been sought in the hope of finding a clue to the nature of the action of the hydrocarbons in initiating malignancy. Another line of attack has been to search for some special chemical or physical property of the hydrocarbons which might be correlated with their biological actions. In recent work a special chemical property has been discovered. It has been found that methylcholanthrene and 3,4-benzpyrene, the most potent of the known carinogenic hydrocarbons, possess chemical reactivity of a specific kind to a degree not previously encountered in any known aromatic hydrocarbons. They show a remarkable susceptibility to substitution reactions, as exemplified in diazo coupling, oxidation with lead tetraacetate, and condensation with methylformanalide. From such results as have been obtained in the brief period since the first recognition of this unsuspected property, it appears that there is at least a rough correlation between the chemical reactivity of the hydrocarbons and their carcinogenic activity. Coupled with biological results indicating that the hydrocarbons undergo rapid chemical reaction in contact with animal tissue, the observations suggest that the first step in the action of a carcinogen in the induction of malignant growth consists in a substitution reaction. It is conceivable that this may consist in a hydroxylation, or in the introduction of a sulfhydryl group or an amino residue. (*Author's abstract.*)

505TH MEETING

The 505th meeting was held in the Auditorium of the Cosmos Club on Thursday, December 8, 1938, with President DRAKE in the chair. The

President announced with sorrow the passing of CHARLES EDWARD MUNROE, in his 89th year, on December 7, 1937. Professor MUNROE was past president of both the Chemical Society of Washington, and of the American Chemical Society. The following resolutions were read into the minutes of the Society:

"In the death of Professor CHARLES EDWARD MUNROE on the afternoon of December 7, 1938, at the age of 89 and a half years, the Chemical Society at Washington has suffered an irreparable loss. During his forty-six years of residence in Washington, Professor MUNROE's activities were so closely interwoven with those of this local society that they constitute an almost unbroken record of service in one connection or another. Immediately after his coming to Washington in 1892 as Professor of Chemistry at Columbian (later George Washington) University, he took an active part in the movement that led to the incorporation of the existing Chemical Society of Washington as a section of the American Chemical Society. In 1896 he became the twelfth president of this Society, and, until the time of his retirement as Chief Explosives Chemist of the Bureau of Mines in 1934, maintained an active interest in all phases of its work. As a charter and life member of the American Chemical Society, and as the oldest of its past presidents, he was regarded not only locally but nationally as the beloved dean of American Chemistry.

Of the many occasions at which Professor MUNROE appeared upon our program, the most memorable was at the 400th meeting on March 29, 1928, when he, Dr. H. W. WILEY, and Dr. F. W. CLARKE, all former presidents of the Society and past presidents of the American Chemical Society, were the speakers and guests of honor. The reminiscences of Professor MUNROE at this meeting, narrated with the delightful charm of manner that was so characteristic of all that he did, are still fresh in the minds of all who were then present.

The great and lasting services of Professor MUNROE to American Chemistry are too well-known to require mention in the present resolution. Be it, however,

Resolved that a Committee of the Chemical Society of Washington be authorized to collaborate with the American Chemical Society in the preparation of a comprehensive review of the contributions of Professor CHARLES EDWARD MUNROE to the Science and Art of Chemistry, and be it also

Resolved that this expression of regret on the death of our fellow member and past president, Professor CHARLES EDWARD MUNROE, be recorded in the minutes of this Society and that a copy thereof be sent with our expressions of sympathy to Mrs. MUNROE and the members of her family."

The meeting was addressed by Professor E. BERL, of the Carnegie Institute of Technology, who spoke on *the practical aspects of cellulose derivatives.* The speaker discussed in detail the preparation, stability, and fabrication of the many industrially important derivatives of cellulose, particularly with respect to their use in synthetic yarns and similar products.

FRANK C. KRACEK, *Secretary*

Obituary

George Herbert Girty, geologist of the Geological Survey and specialist on Carboniferous and Permian formations and faunas, died at his home, 3600 Macomb Street, N.W., Washington, D. C., on Friday, January 27, of a heart ailment. Doctor Girty was born December 30, 1869, in Cleveland, Ohio. He was educated in the public schools of Cleveland, and at Yale University. He received his A.B. from Yale in 1892, and his Ph.D. in 1894. He joined the staff of the Geological Survey in 1895, and was a valued member of that organization continuously from then until his death, a period of 44 years.

Doctor Girty made field investigations of Carboniferous and Permian rocks in nearly all states and territories in which they occurred, and described the invertebrate faunas of the formations studied. More than any other man, Doctor Girty laid the broad foundations for the present day interpretations of the Carboniferous geology of the West and Southwest, as well as for Alaska. He is most widely known for his classical studies of the Permian faunas of Texas, but nearly all of his papers are used and cited throughout the world. He was the author or part author of 9 Professional Papers and 12 Bulletins of the Survey, and of about 50 other articles. His written opinions and memoranda on Carboniferous problems, most of which are printed in the reports of his colleagues, must approach a thousand.

Doctor Girty was a member of the American Association for the Advancement of Science, the Geological Society of America, the Paleontological Society, the Washington Academy of Science, the Geological Society of Washington, and Phi Beta Kappa.

A direct, penetrating thinker, a critic who could detect fallacy with unerring accuracy, no matter how subtly or elaborately it was camouflaged, a man with a strong sense of justice and fairplay, frank, honest, faithful, George H. Girty will be sadly missed in his profession and among his friends.

Charles Edward Munroe, dean emeritus of the School of Graduate Studies of George Washington University, died at his home in Forest Glen, Maryland, on the afternoon of December 7, 1938. Dr. Munroe was born at Cambridge, Mass., May 24, 1849. He graduated *summa cum laude* from Harvard in 1871, and for the next three years taught chemistry there and established the first course in chemical technology. He left Harvard in 1874 to accept the professorship of chemistry at the United States Naval Academy, where he remained until 1886. He next served as chemist of the United States Naval Torpedo Station and War College at Newport, R. I. In 1892 he became Professor of Chemistry and also served as Dean of the Graduate School of George Washington University until his retirement in 1918.

Dr. Munroe was the inventor of the smokeless powder "Indurite." He was engaged in many public services. His copious reports for the censuses of 1900, 1905, and 1910, as expert agent in charge of chemical industries, are invaluable for their wealth of historical and statistical information. He served also at various times as consulting expert for the U. S. Geological Survey, the U. S. Forestry Service and the Civil Service Commission, and was chairman of the advisory committee of the American Railway Association for drafting regulations on the safe transportation of explosives. He was chairman of the Committee on Explosives of the American Society of Testing Materials and also of the Committee on Explosives Investigations of the National Research Council. No less extensive were Munroe's services for the numerous scientific societies of which he was a member. In 1873 at the meeting of the American Association for the Advancement of Science in Portland, Maine, he was secretary of a group of distinguished chemists (among whom were seven future presidents of the American Chemical Society) who petitioned the Association for the formation of a subsection of Chemistry. He was also the last surviving charter member of the American Chemical Society (founded in 1876) which honored him with its presidency in 1898. His services to this body, of which he was a life member, were of the highest order. He served continuously as Associate Editor on Explosives for Chemical Abstracts from the first issue of this Journal in 1907 until death terminated the activity of his pen.

In addition to the various domestic and foreign chemical societies to which he belonged, Munroe was a member of the American Association for the Advancement of Science, the American Philosophical Society, the American Academy of Arts and Sciences, and an honorary member of the Washington Academy of Science. He was a recipient of numerous honors, among which were a membership of the Turkish Order of Medjidieh and a decoration of the Order of Leopold from Belgium.

EDMUND CECIL SHOREY passed away, after a period of illness, on Monday, January 30, at Emergency Hospital, Washington, D. C. Dr. Shorey was born in Lanark County, Ontario, on March 5, 1865. He secured both his undergraduate and graduate education at Queens University, Kingston, Ontario, with the B.A. degree in 1886, the M.A. in 1887, and the D.Sc. in 1896. This institution also honored him with a gold medal in chemistry and a silver medal in natural science. For the year following his graduation he was connected with Queens University as a demonstrator in chemistry. From 1888 to 1891, he was engaged in private analytical work and assaying. Dr. Shorey entered the field of industrial chemistry when he became chemist for the Kohala Sugar Company of Hawaii. In 1899 he was appointed Chemist of the Territory of Hawaii and served in this capacity until 1903, when he became Chemist of the Hawaii Agricultural Experiment Station. After four years with this institution he was transferred to the Division of Soil Fertility Investigations, Bureau of Soils, U. S. Department of Agriculture. His long association with the Department was only interrupted by a brief return to commercial research in 1918 to 1921. In the Division of Soil Fertility Investigations he attained the rank of Senior Biochemist, and, upon retirement in 1935, remained as a Collaborator.

Dr. Shorey's chief interest and activity in chemical research was the biochemical aspect of the organic matter of soils as related to plants. This research is covered by numerous papers and bulletins and the results of this work gained him international recognition. His intense interest in this field of organic chemistry was maintained until the last, as evidenced by the publication last March of his work upon the isolation and identification of allantoin from several soils.

Dr. Shorey was a fellow of the American Institute of Chemists, and a member of the American Association for the Advancement of Science, the American Chemical Society, the Society of Biological Chemists, and the Washington Academy of Sciences.

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JOURNAL

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Journal of the Washington Academy of Sciences

This Journal, the official organ of the Washington Academy of Sciences, publishes: (1) short original papers, written or communicated by members of the Academy; (2) proceedings and programs of meetings of the Academy and affiliated societies; (3) notes of events connected with the scientific life of Washington. The Journal is issued monthly, on the fifteenth of each month. Volumes correspond to calendar years.

Manuscripts may be sent to any member of the Board of Editors. It is urgently requested that contributors consult the latest numbers of the Journal and conform their manuscripts to the usage found there as regards arrangement of title, subheads, synonymies, footnotes, tables, bibliography, legends for illustrations, and other matter. Manuscripts should be typewritten, double-spaced, on good paper. Footnotes should be numbered serially in pencil and submitted on a separate sheet. The editors do not assume responsibility for the ideas expressed by the author, nor can they undertake to correct other than obvious minor errors.

Illustrations in excess of one full-page halftone or two full-page line drawings may be paid for by the author. Line drawings are preferred.

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Copies	4 pp	8 pp	12 pp.	16 pp.	Covers
50	....	....	....	....	$2.00
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200	1.75	2.60	3.60	4.50	4.25
250	2.00	3.30	4.65	5.75	5.00

Envelopes for mailing reprints with the author's name and address printed in the corner may be obtained at the following prices: First 100, $4.00; additional 100, $1.00.

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Missing Numbers will be replaced without charge provided that claim is made to the Treasurer within thirty days after date of following issue.

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Corresponding Secretary: Nathan R. Smith, Bureau of Plant Industry.
Recording Secretary: Oscar S. Adams, Coast and Geodetic Survey.
Treasurer: Henry G. Avers, Coast and Geodetic Survey.

JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

Vol. 29 May 15, 1939 No. 5

GEOPHYSICS.—*From the center of the earth to the sun.*[1] N. H. Heck, U. S. Coast and Geodetic Survey.

It is customary for the retiring president to select a subject related to his work. When that work deals with the broad phases of both terrestrial magnetism and seismology, the logical procedure is to present a broad review rather than the results of his individual endeavor.

The theme "From the Center of the Earth to the Sun" might be construed as dealing with the whole field of science, but the subject of the present paper is narrowly restricted to what can be learned from observations in seismology and terrestrial magnetism about the interior of the earth, its atmosphere, and the sun. While the principal findings have all been announced, appraisal of their validity is needed in some cases. An opportunity is also afforded to discuss errors of observation as related to the recently developed need for higher accuracy.

Since the work in both subjects is highly cooperative, the historical background, especially in the United States, must be understood. In the case of terrestrial magnetism, the Coast and Geodetic Survey (hereinafter referred to as the Coast Survey) has been making observations for more than 100 years, and for nearly 40 years there has been an effective program, including the magnetic survey, the repeat program at 5- to 10-year intervals, and the operation of five widely separated magnetic observatories. Its great contribution has been in putting this information into convenient form for use by investigators.

Much of the interpretation of this and of other data from all over the earth has been done by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington (hereinafter referred to as the Carnegie Institution), whose main purpose is the investigation of the subject of terrestrial magnetism in relation to other phenomena and for the earth as a whole. It is well known that its program has included observations in a number of lands where no magnetic sur-

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[1] Address of the retiring president of the Philosophical Society of Washington, delivered January 14, 1939. Received March 27, 1939.

vey exists, the operation of two well-equipped observatories in foreign countries, and, for many years, magnetic observations at sea.

For the earth as a whole many nations engage in both magnetic observation and interpretation of the results. Among these Great Britain, Germany, and some of the other nations of northwestern Europe have been outstanding. There are in all about 80 magnetic observatories.

The situation in seismology is evidenced by the existence of more than 400 stations for recording earthquakes scattered over the earth, but the majority of them and most of the interpretative work have been in Europe and Japan. Only recently has the United States begun to take an outstanding place. Contributions to knowledge of the interior of the earth have come from organized groups in California, the Mississippi Valley, Washington, D.C., and New England. The Coast Survey has been engaged in direct and cooperative operation of observatories, interpretation of their records, location of the places of origin of earthquakes, and in the measurement of strong earth motions.

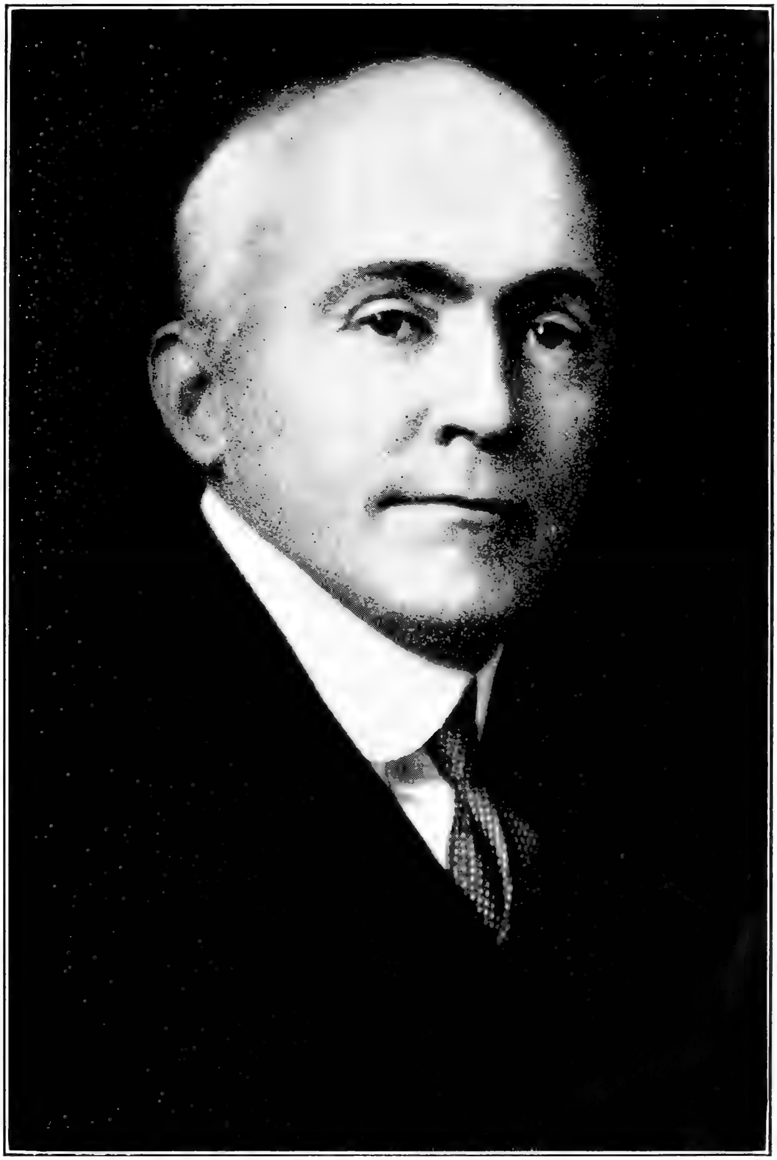
Since the earth sciences necessarily deal with the earth as a whole, generalization from limited observational data is necessary. In the case of both terrestrial magnetism and seismology, the necessity of having continuous observations of high accuracy, aside from all questions of cost, places a definite limitation on the number and spacing of the places of observation. It is most important that observations be sufficiently accurate to meet all present and future requirements.

ERRORS IN OBSERVATION

Errors in observation will lead to erroneous conclusions, and the use of statistical methods cannot remedy basic defects. Complete discussion would be too long, and consideration of time in seismology and of absolute measurements in terrestrial magnetism will have to serve to bring out the essential points.

Errors of Time in Seismological Records

In seismology time is related: to earthquake location, both in position and depth; to the physical characteristics of the earth's interior; and to the verification and location of surfaces of discontinuity. The source of this information is the travel time curve, in which the time of wave transmission from place of origin of earthquake to recording station is plotted against distance, or the equivalent table. The effect



Nicholas H. Heck
President, Philosophical Society of Washington
1938

of a given error in time varies in different parts of the curves and tables and may be very large.

The needed accuracy of time as scaled from the records (0.1 or 1.0 second, as earthquakes are near or distant) may seem readily obtainable, but accuracy attained without difficulty under favorable conditions may be almost unattainable, or incapable of being maintained, at remote stations, because of mechanical and electrical difficulties.

The requirements are that a drum be turned at a uniform rate by synchronous motor or by clockwork preferably controlled by a suitable governor; time marks must be placed at uniform intervals; and the time must be absolute. Electric current with accurate frequency control is by no means universal, time-marking chronometers have varying rates, and the frequent United States Naval Observatory time signals, indispensable as they are to seismologists, cannot in themselves provide continuous absolute time. The use of a radio signal to mark the same instant on all the records of a network of stations suggests the recording of continuous time signals, but it has not been found practicable to use the second-by-second signals of the Dominion Observatory, Ottawa, Canada, or the frequency control signals of the National Bureau of Standards for this purpose. Even if suitable minute-by-minute signals were available, provision would have to be made for failure of radio reception.

In addition to the control errors, there is also the error in selecting the exact time of beginning of an activity, a problem common to both seismological and magnetic records. The identification of the beginning of an earthquake phase or of a sudden commencement of a magnetic storm depends in a large measure on the sharpness of the arrival, that is, the slope (Fig. 1). Very sharp arrivals can be determined with great accuracy, but emergences with flat slopes or complex arrivals are not easy to measure precisely. In the case of earthquakes the presence of microseisms may make phase identification difficult. Seismological stations have been appraised as having inaccurate time control when the errors in interpretation were due to microseisms.

An open time scale is helpful, but it is a fallacy to assume that the more open the scale the greater necessarily the accuracy. With too great increase the steep slopes may become relatively flat. The quick run magnetic recorder of La Cour with a speed of 180 mm per hour as against the 15 or 20 mm per hour in customary use makes it possible to determine the time of certain arrivals with great accuracy, but the records as a whole are difficult to interpret and cannot be satisfactorily used in filling gaps in records with the ordinary time scale.

Each individual seismological record is complete in itself as a source of seismological data, its limitations depending solely on the quality of the installation and the standards of operation.

Errors in Conversion from Relative to Absolute Magnetic Values

In the case of terrestrial magnetism, the errors to be discussed are those related to the conversion from relative to absolute values. Since no means has been found to make continuous absolute observations of the magnetic elements, the continuous records are relative and can afford absolute values only through absolute determinations at suitable intervals. Certain investigations in terrestrial magnetism appear to require only relative values, but full reliance cannot be placed on their accuracy without control by absolute observations.

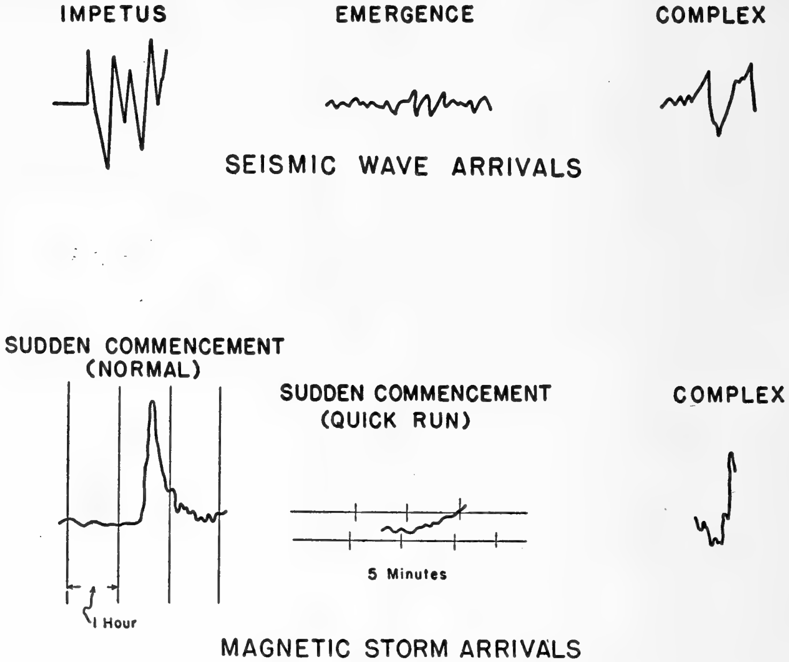


Fig. 1.—Records of seismic wave arrivals and of magnetic storm arrivals.

The relative values themselves have their own sources of error, especially instrumental imperfections and uncertainty in the elimination of temperature effects (in the case of intensity). There is some attempt at temperature and humidity control at most observatories, but at remote places laboratory conditions cannot be reproduced. There are similar errors in the absolute determinations, and there are other sources of error. In the Gauss method of measuring horizontal intensity, which is still in general use in spite of the adoption of electrical apparatus at a limited number of observatories, the observations require considerable time, during which the element may change in an irregular manner. Horizontal intensity requires two distinct observations (oscillations and deflections), and vertical intensity depends on the further measurement of dip. Each has its own source of error. Furthermore, only one element can be measured at any given point at the same instant.

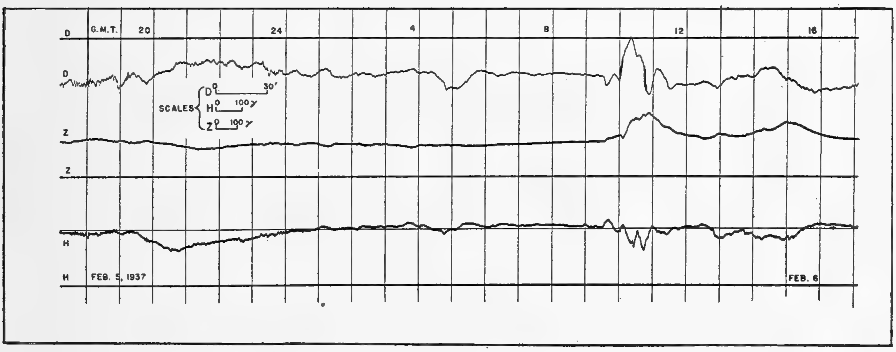


Fig. 2.—Record of magnetic variation. Abscissae represent time in hours; ordinates represent D, H, and Z, with scales as indicated.

The assignment of correct absolute values to the baseline (straight line of reference on the magnetogram, Fig. 2) is affected not only by the errors of observation but by the comparative infrequency of absolute determinations at most observatories. At Abinger, England, several determinations are made each day, but such procedure is rarely feasible. There is always the possibility of a sudden change in the position of the variometer magnet due to some mechanical change, which affects the proper assignment of baseline values. Temperature compensation is not always perfect.

In a different class of error the magnets may not be in the plane in which they should operate, in which case they measure the change in the resultant of two elements rather than of a single element. Recent examination with more refined methods shows that many instruments had magnetic parts near the magnet. Good progress is being made in eliminating these sources of error.

Though the list of possible errors sounds formidable, in practice the results are good. However, the degree of accuracy attempted—0.1

minute in declination and dip and 1 gamma (10^{-5} gauss) in intensity —is consistently obtained at few observatories, and there are cases of gross error. Eternal vigilance is the price of accuracy.

Standardization

Even if precise data were available from every observatory, errors sufficient to affect adopted theories might arise from differences in standards. The Carnegie Institution has adopted an international standard, which is now maintained at Cheltenham jointly with the Coast Survey and the National Bureau of Standards. The use of the sine galvanometer of the Carnegie Institution at Cheltenham to determine horizontal intensity has enhanced the value of the results. A series of intercomparisons has been going on for years between United States observatories by the Coast Survey and internationally by the Carnegie Institution. Recently La Cour, director of the Meteorological Service of Denmark, has suggested more frequent intercomparisons by means of instruments developed under his direction, and some comparisons have been made between Denmark and the United States and elsewhere.

At places other than observatories in general only absolute observations are possible, though the Carnegie Institution makes diurnal variation observations over short periods and the Coast Survey is developing a portable observatory to operate about two weeks at a site. In most cases correction for magnetic changes must be deduced from the records of a distant observatory. V. Vacquier, of the Gulf Research Laboratories, has shown in the case of vertical intensity that on certain days this practice will lead to erroneous results, because of local variations which may extend over a distance of 300–500 miles. Fig. 3 shows changes in vertical intensity on a given day from Cheltenham, Md., to Tucson, Ariz., magnetic observatories.

The demand for accurate determination of the magnetic elements, especially vertical intensity, has grown, since the measurement of that element has proved to be a useful method of discovering geological formations associated with oil and minerals. The anomalous situation exists that differences are more accurate than absolute values. Such detailed surveys would be more valuable if the values were absolute. The stress that has been laid on the reduction or elimination of errors may seem excessive, but it is based on a conviction that one of the important needs is steady improvement in instruments and methods by all agencies engaged in magnetic and seismological work. The Coast Survey is committed to such a program.

INTERIOR OF THE EARTH FROM SEISMOLOGY

The principal facts that are needed regarding the interior of the earth are the viscosity, density, elasticity, temperature, pressure, liquid or solid condition, gradual or sudden change of physical condition, and especially whether the earth consists of a series of concentric shells. For the deep interior the passage of earthquake waves is the principal and perhaps the only source of detailed information, though certain facts can be deduced from other sources. The transmission of the waves follows definite laws fixed by the condition of the medium traversed, which it therefore reveals. In some cases seismology merely reduces the number of unknown factors and indicates a possible solution.

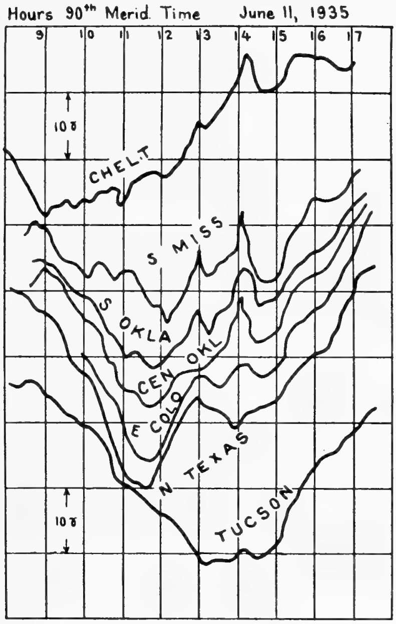


Fig. 3.—Simultaneous variations in vertical magnetic intensity.

Of the desired facts listed regarding the interior of the earth, seismology gives definite evidence of change of condition, especially through the location of layers of discontinuity; gives some idea of elasticity, compressibility, density, and rigidity; tells little about temperature and pressure; and tells that the earth is solid with the possible exception of the core, whose solidity remains somewhat doubtful.

If conditions within the earth were known, travel time curves could be computed from theory alone. The approach to the problem is quite different. Seismological stations in many parts of the earth have furnished a vast number of records of earthquakes at every possible distance from the recording station. These records give transmission times, and by means of suitable mathematical treatment and certain broad assumptions velocity can be deduced for every part of the path traversed. This makes possible the accurate location of earthquakes whether of normal depth or deep focus, and also knowledge regarding the interior of the earth, since assumptions regarding it must fit the observed times. In recent years the process of correlation and interpretation has been accelerated, and probably the major portion of the arriving phases have been identified.

There are two methods of attack. One is by studying a single earthquake, using records from all parts of the earth, which brings out differences in transmission in various regions. The other, an older method, is to average the results of a large number of determinations from earthquakes recorded at similar distances. Seismologists have used both methods in preparing various travel time tables, which are by no means in agreement with one another.

Seismology makes it possible to compute the density of the earth at different depths, that at the surface and the mean density of the earth being known in other ways. Values of special interest as given by Bullen for given depths are as follows: 42 km, 3.32; 2,800 km, 5.50; 3,000 km, 9.82; center of earth 12.17. Mean value for the earth is 5.52; for core 10.76; and for portion outside of the core, 4.49.

Seismology tells little about the temperature, though it is an important element in fixing the conditions of earthquake wave transmission. This lack of information is especially regrettable because the question whether the temperature continues to increase at the rates given by measurements in wells down to 15,000 feet is important in magnetism as well as in seismology.

Laboratory procedure is giving useful information regarding probable conditions in the earth's crust. Pressures now available (about 50,000 atmospheres) correspond to the depth of about 100 miles, but only limited application has as yet been made to seismology.

Core

One of the best-established facts in seismology is the existence of a core with its surface at a depth of 2,900 km (Fig. 4), so that its diameter is a little more than half that of the earth, and it contains one-sixth of its volume. The core is known both through the determination of the position of its surface and because the velocities within it are very different from those outside of it. The velocity, according to Gutenberg and Richter, changes suddenly at the boundary of the core from 13.7 to 8 km per second, and within the core it increases to 11.4 km at 5,150 km depth and remains practically unchanged to the center of the earth. The question whether the core is liquid or solid is still an open one. Brunner states that he has found no absence of activity at proper places on the record for arrival of transverse waves through the core but rather too much activity and none of it outstanding. The inference is that if these waves traverse the core they carry little energy.

The question whether the core, like many meteorites, consists of iron and nickel may be of importance in connection with terrestrial magnetism. The evidence for such composition has often been given and seems quite satisfactory. Jeffreys has stated that if the pressure could be removed the density of the core would be equal to that of iron at the surface. The discontinuity at the surface of the core seems fairly sharp. Certainly there are no great irregularities in the transition.

Mantle

That part of the earth which lies between the core and the bottom of the crust is known as the mantle. It has no major discontinuity, but it seems to have several minor ones which probably indicate sudden change of physical condition in addition to the gradual change with depth, a characteristic of the mantle. Various discontinuities have been suggested, those receiving most consideration at present being at about 1,000 and 400 km (Fig. 4). It is noted that the 400 km discontinuity, if real, is of less depth than the deeper of the deep-focus earthquakes, which reach 700 km. However, the layer of discontinuity is presumed to extend around the earth, while the deeper earthquakes are confined to areas of limited extent. The general distinction between the crust and the mantle is that the conditions in the mantle are nearly the same everywhere at the same distance from the center of the earth, while the crust is quite variable. Regional anomalies in transmission of waves through the earth indicate that in some regions there are differences which may extend into the mantle.

Deep-focus earthquakes are confined to a portion of the rim of the Pacific Ocean with a few exceptions (Fig. 5). The criteria by which they are recognized are that their phases do not fit the tables for normal earthquakes with depths of 50 km while proper assumption of

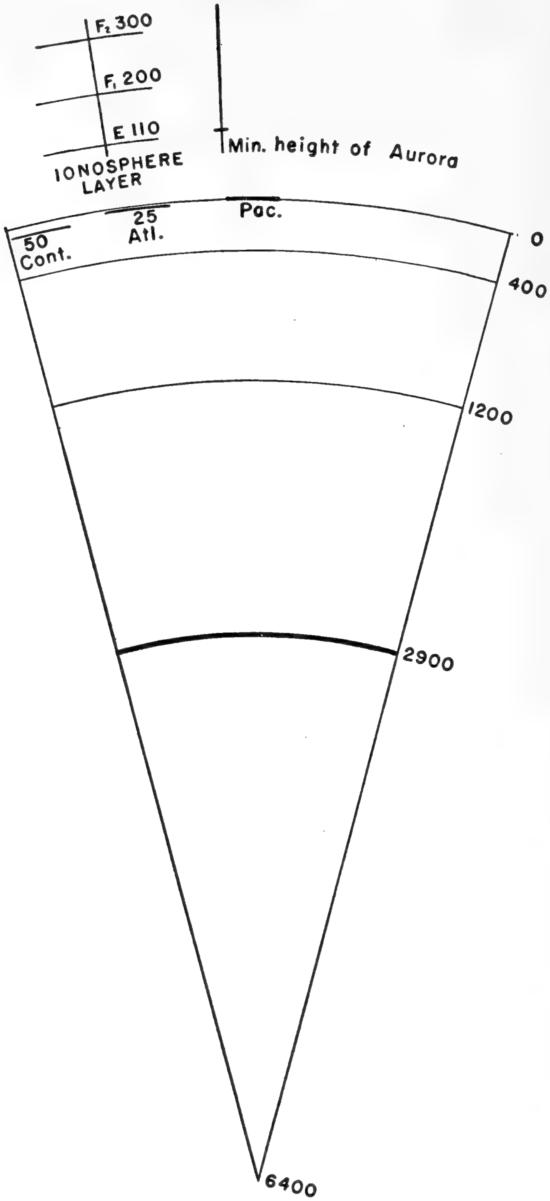


Fig. 4.—Concentric layers in earth and atmosphere.

depth gives satisfactory values; and that there is almost complete or complete lack of surface waves. They often exhibit an unexplained phenomenon: Waves which have gone from focus to surface and there been reflected arrive with more energy than the direct waves from the focus.

The deep-focus earthquake seems to conflict with the theory of isostasy as there should be no possibility of building up of stress below the depth of compensation, which at most is held to be less than 100 km. However, these earthquakes act like tectonic and not volcanic or explosive types, so that there must be gradual building up of stress. Gutenberg has pointed out that while there may be no strength at such depths there is viscosity, so that a rapidly developing stress might suddenly overcome the resistance with resultant earthquake.

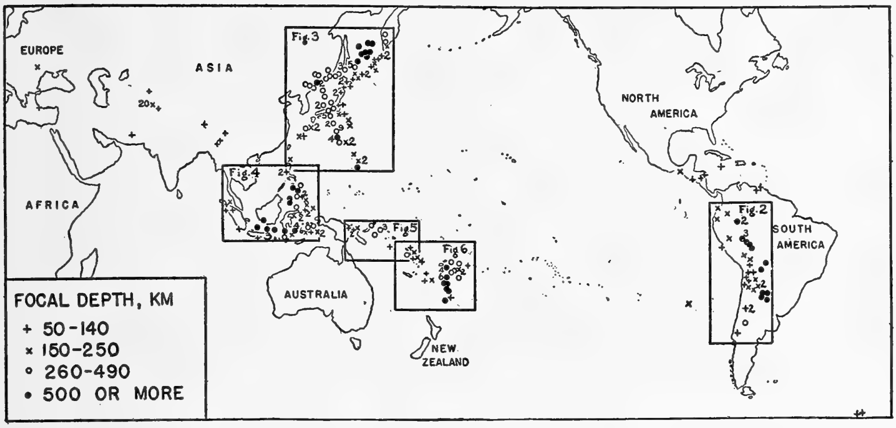


Fig. 5.—Deep-focus earthquakes. Numbers attached to symbols represent two or more shocks from nearly the same source. (Courtesy Geological Society of America.)

Crust

The crust of the earth is only a small portion of its volume, but it is of extreme importance from the human viewpoint, from the fact that its surface is the platform on which all magnetic and seismological observations are made and because it is itself infinitely more varied in structure than the rest of the earth, the variety in general increasing toward the surface. All except deep-focus earthquakes, which are a small proportion of the whole number, occur within the crust. The effects of the severe earthquakes in causing damage and aiding in the processes that bring about geological change constitute the principal reason for earthquake observations from which scientific information regarding them is obtained.

For the region immediately beneath the surface, whether on land or under the ocean bottom, information has been obtained by the use of artificial seismic methods based on explosions. Additional information has been found in regard to the surface layers on land through the measurement of strong earthquake motions and the use of vibrating machines and highly sensitive recording apparatus. The Coast Survey has obtained important results in these two fields.

Thickness of the Crust from Isostasy

The thickness of the earth's crust is uncertain, since it can be determined only by geophysical methods, and different methods give different results. The theory of isostasy, according to the Pratt hypothesis (Fig. 6), gives a rather uniform thickness of crust except for surface variations in height, since computations give a depth a little less than 100 km. This is the simplest of all conceptions of the crust. The Airy hypothesis of isostasy calls for uniform depths over considerable areas, the greatest depths being beneath the mountain areas. A difficulty in choosing between the two arises from the fact that an accurate depth of compensation can be computed only for a mountain and not for a flat area. Byerly has found from seismic evidence that the Sierra Nevada in southern California have a granite root projecting perhaps 20 km below the normal depth for granite. The continental layer is deeper beneath the Alps than the rest of Europe. This might seem to give indirect evidence in favor of the Airy hypothesis. Macelwane also favors it for seismological reasons.

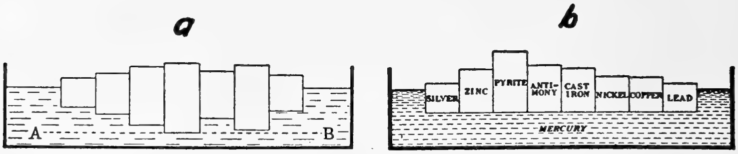


Fig. 6.—(a) Illustrates Airy or "roots of mountains" theory; (b) illustrates Pratt theory.

As to the exactness of the depth of compensation adopted, the computations permit some degree of latitude. Furthermore, while isostasy expresses the view that the crust has a strong tendency to equilibrium at a certain depth, perfect equilibrium can never be attained so long as meteorological processes, with their consequent shift of load on the earth's crust, continue.

Thickness of Crust from Seismology

The crust derived from seismology is quite different from that just described. Seismic waves give evidence of its thickness in several ways, but only one method gives quantitative results—the use of travel time curves of the several parts of the preliminary waves from earthquakes within a few hundred kilometers. This method is well established and is responsible for the determinations of Jeffreys and

Mohorovicic in Europe and of Gutenberg in California. Instruments for recording nearby earthquakes and time correct to 0.1 second are needed. These conditions are met only in a few regions.

Surface waves in spite of their complexity give some information regarding the crust. They indicate the great difference in the Pacific Ocean basin, since the surface waves traversing it have a speed nearly 20 percent higher than for the continents. They give evidence of a vertical surface of discontinuity of moderate depth around the Pacific which corresponds to the major earthquake belt. Other applications give promise.

Results from various sources are given in Table 1. They are clearly preliminary and highly generalized. The broad picture includes double or multiple continental layers aggregating 40–50 km, becoming less toward the borders; a total depth of 20–25 km for the non-Pacific type of ocean bottom and no similar layer at all for the Pacific. Needed detail is lacking at every point.

TABLE 1.—THICKNESS OF CONTINENTAL LAYER (ACCORDING TO GUTENBERG)

Locality	Continental crust (depth in kilometers)
England	20
Southern Germany	45
Eastern Alps	50
Southeastern Europe	About 45
Caucasus	About 45?
Central Asia (region of 40° N., 70° E.)	40–50
Philippine Islands	About 50?
Japan	About 50, decreasing toward the Pacific
Southern and central California	30–40

The complications are well illustrated by an approximately correct section of the crust in the vicinity of Japan, which, however, omits the geological details (Fig. 7). The depth of compensation is highly approximate, since it cannot be determined accurately in such a varied region with great gravity anomalies.

In regard to the coordination of the two conceptions, it must be remembered: first, that the depth of compensation is rather indefinite, with rather wide possible limits; and second, that there seems to be no reason why there should necessarily be at the depth of compensation sharp physical changes which would produce a surface of discontinuity. Besides, there appears to be no discontinuity beneath the Pacific.

It seems best for the present to accept the viewpoint that the two conceptions cannot be completely reconciled, but neither isostasists nor seismologists should abandon hope of a more satisfactory future conclusion.

TERRESTRIAL MAGNETISM AND THE EARTH

Although terrestrial magnetism is to serve as a bridge from the earth to the atmosphere and to the sun, it is largely of the earth. The surface magnetic field resembles approximately that of a weakly but permanently magnetized sphere of the same size as the earth, but it is not so simple. Bauer has shown that about 94 percent of the earth's surface field originates within the earth. If the meaning of this were fully understood magnetism might become a competitor with seismology in giving facts about the earth's interior.

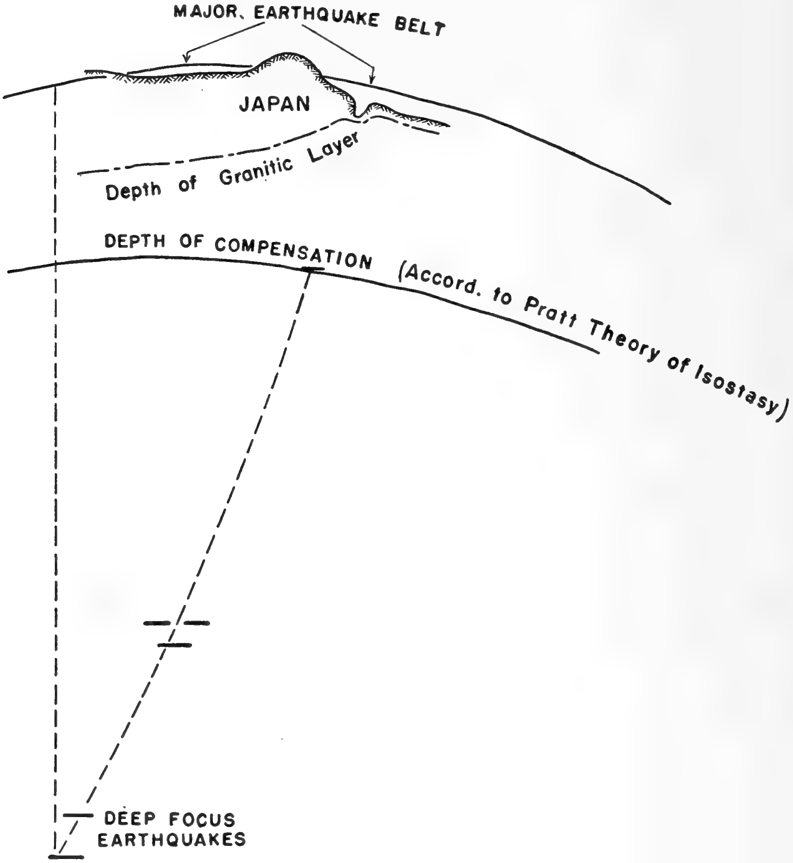


Fig. 7.—Section of earth's crust near Japan.

Since the magnetism is not uniformly distributed and since part of it comes from outside the earth, it is fortunate that the more or less rapid changes which add to the complexity also contribute to the solution of some of the problems.

The part of the earth's surface field that is not from within the earth is due to varying and also possibly to constant stationary current systems in the earth's atmosphere, and it is a source of information in regard to the atmosphere and the sun. The varying electrical currents flowing in the atmosphere induce currents within the earth and therefore contribute to the observed surface field of internal origin. If this part is removed from the surface field of internal origin, the remainder is called the earth's main field; its surface values are given with all the accuracy needed for most purposes by the magnetic maps used by navigators and surveyors. Its cause is unknown at present and constitutes one of the greatest of the unsolved problems of physics.

The continuous recording at magnetic observatories supplemented by measurements at selected points at 5- to 10-year intervals gives a continuous picture of the earth's surface magnetic field in its entirety. The observatories are badly distributed, with overconcentration in Europe and sparsity in other parts of the earth, especially in the Southern Hemisphere and the polar regions. The five observatories of the Coast Survey and two of the Carnegie Institution are in regions of few observatories. In the case of the polar regions, a temporary network of observatories was operated during the so-called Polar Years of 1882–83 and 1932–33, and chiefly in the north polar region.

This uneven distribution of observatories has placed a heavy burden on the repeat work of the magnetic survey. Various governments including that of the United States have done their share, but since 1905 the magnetic survey of land areas not so taken care of and of ocean areas has been carried on by the Carnegie Institution. Since the loss of its nonmagnetic ship *Carnegie* in 1929, the ocean survey has stopped, but it is expected to be resumed when the British Government's nonmagnetic ship *Research* takes up the ocean work. This is especially important since any serious lack of continuity not only detracts from present knowledge but destroys some of the value of observations made in the past at great cost. The United States should have a small nonmagnetic ship to work in waters adjacent to its coasts.

Main Field and Secular Variation

The main field and secular variation have been studied by an application of the method of spherical harmonic analysis due to Gauss and developed by others. A uniformly magnetized sphere of the same size as the earth gives a good first approximation. Its north pole known as the geomagnetic north pole is near Smiths Sound, Greenland, about 12° from the geographic north pole (Fig. 8). This is different from the north pole of 90° dip or north magnetic pole, located on Boothia Peninsula, north Canada. The field, at points in space, is that of a short magnet or dipole near the center of the earth, and it varies inversely as the cube of the distance from that point. This is the regular part, and the more irregular complicated part varies more

Fig. 8.—Earth poles and auroral belt.

rapidly with distance and is negligible at a few hundred miles above the earth. At the surface of the ground the contribution of the irregular portion may be very large and is an important factor in the tracing of isomagnetic lines, which even in slightly disturbed areas can be drawn only approximately if the survey is not in great detail. In general, there is merely a distortion of the isomagnetic lines (Fig. 9), but in some cases there may be a local magnetic pole. In some places interpretation gives the approximate depth to the basement rock and other valuable geological information.

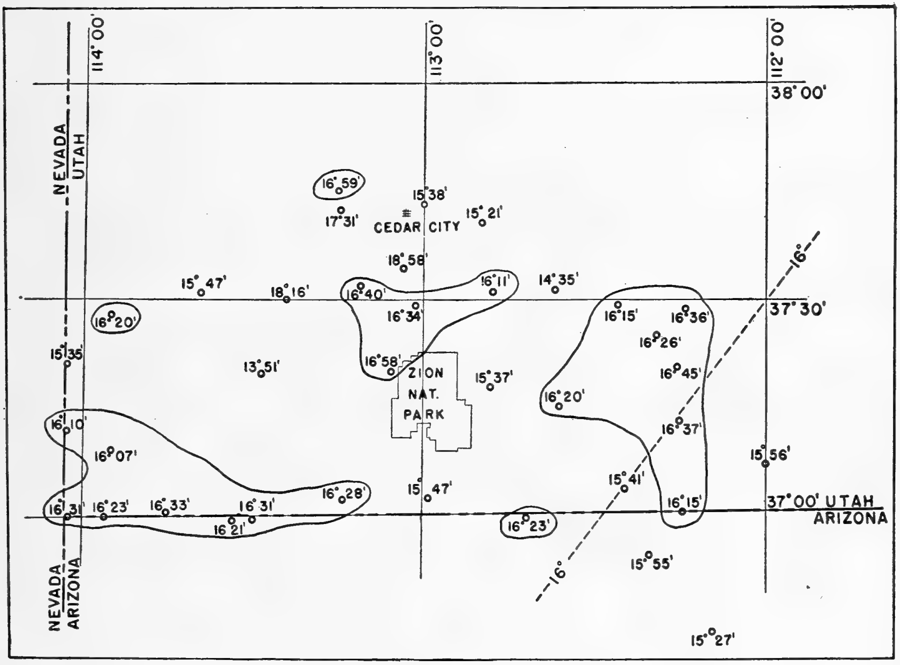


Fig. 9.—Area of disturbance in magnetic declination.

Closely allied with the problem of the origin of the main field is that of its secular variation or change with time. Measured data giving its characteristics are as yet scanty, since its more noteworthy changes with time are slow and completed only throughout the course of centuries. Our records are most complete for the magnetic declination or the departure of the compass direction from the true north. In declination, a complete cycle is defined as a return to the original position after excursions to extreme positions on either side. The duration of a cycle is, according to data available for western Europe and for the eastern United States, of the order from 300 to 500 years or more. It would be more desirable to deal with the values of total magnetic force, thus using both intensity and direction of the field; this is possible for a period of less than 100 years, and over a much shorter period of time for the earth as a whole.

As in seismology the difficulty is in the present impossibility of direct observation of physical conditions deep within the earth. If the regular part of the earth's magnetism is ascribed to uniform magnetization throughout its volume, the required intensity of magnetization is much greater than that of the surface layers. Reasons have been given for supposing that the earth's temperature increases progressively with depth. Since iron loses its magnetism at about 800° C (Curie point), it appears improbable that ferro-magnetic materials are magnetic at any but moderate depths. The experiments of Adams and Green with pressure up to several thousand atmospheres did not indicate any important change of the Curie point with increasing pressure. However, laboratory conditions cannot approximate the unknown conditions at considerable depths. The possibility that the magnetism of the subatomic structure might afford a possible explanation of the earth's magnetism has led to extensive experiments by the Carnegie Institution.

Other efforts have been made to obtain a knowledge of the secular variation over much longer intervals in the earth's history, through the study of igneous and sedimentary rocks. The method of determining the direction of the magnetism in lava on the assumption that it took the direction of the earth's field while cooling involves many uncertainties. The method is more successful when applied to sedimentary deposits. Sediments are formed usually by small particles dropping through the water of oceans and lakes, and if these are magnetic and not influenced too greatly by currents, they will tend to align themselves in the direction fixed by the earth's field at the time. Piggott's cores of the ocean bottom and carefully selected lake varves have given McNish and Johnson, of the Carnegie Institution, an opportunity to investigate this possibility. The preliminary results indicate that the method has great possibilities, especially since in the case of lake varves the time can be identified over many thousand years.

The continuous record of secular change at the observatories of the Coast Survey (Fig. 10) show fluctuations from year to year which are real. These fluctuations would undoubtedly be useful in determining the nature of secular change if they could be correlated with other phenomena.

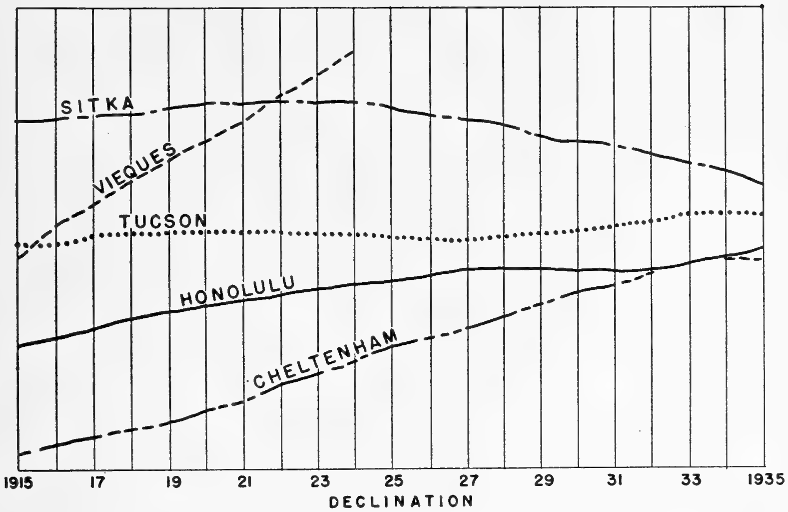


Fig. 10.—Secular variation at United States observatories.

Isopors

Fisk, of the Carnegie Institution, was the first to plot isopors (lines of equal annual change) for the earth as a whole and to prepare world maps. He did this for all elements for the year 1925, the isopors being necessarily approximate because of limited data. He found a considerable number of isoporic foci or regions of maximum change. Later observations were made in South Africa, and the change in the position of the foci between 1927 and 1937 is shown (Fig. 11). In 1936

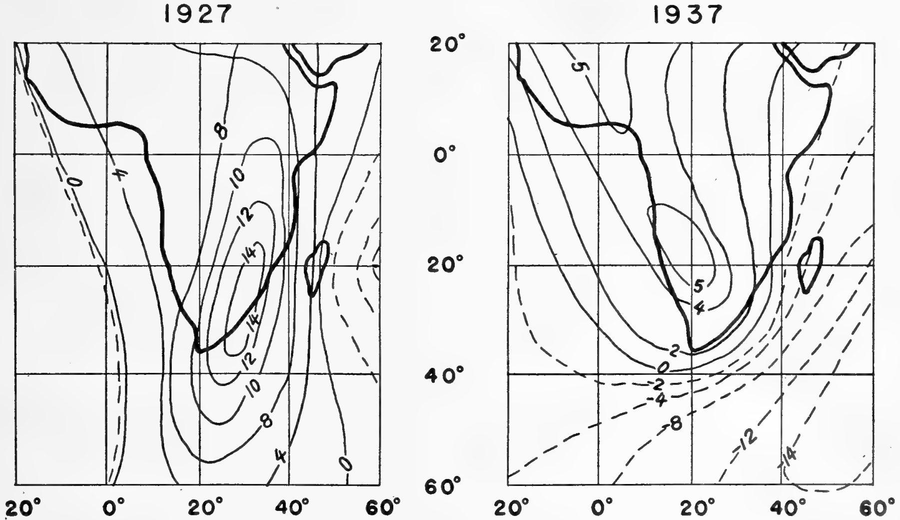


Fig. 11.—Isoporic focus in declination at South Africa.

Heck plotted the results of the Coast Survey and cooperators in the United States for a period of 155 years in declination and of 80 years in horizontal intensity. He found some indications of the movements of minor foci and also of the major foci outside the region.

It is evident that the greater part of the secular variation is local and not world-wide. Furthermore, centers of maximum change are permanent neither in position nor amount, and they may even disappear. Isopors of the different elements may change at different rates. If total-intensity isopors were drawn in intensity and direction, the maps would present a different picture, but the relation of isoporic foci to continents and oceans would not be changed. The important foci are found in the land or the Atlantic and Indian Oceans, and those in the Pacific are moderate.

The cause of secular variation is as yet unexplained. The indication is that marked changes of some kind are going on within the earth, but the nature of these changes is still a matter for speculation.

TERRESTRIAL MAGNETISM AND THE ATMOSPHERE

We next consider the relations between terrestrial magnetism and the atmosphere. Even though there are extensive data, many of these relationships are complex and difficult to understand. The interrelated elements of the problem include: the atmosphere with its varying complex conditions; radio transmission and the ionosphere; current-systems in the upper atmosphere; aurora; magnetic storms of normal or bay form; pulsations; disturbances associated with radio fade-out; cosmic rays; and many of these are closely related and affected in an important way by radiations from the sun.

Solar Diurnal Variation

We must first consider the relation of the solar or quiet-day diurnal variation of the earth's magnetism to the atmosphere. The most fruitful results bearing on the problem have been secured through the study of this quiet-day diurnal variation. On such days the earth's varying field shows only relatively small and simple changes. In the Northern Hemisphere its effect can be most simply described as causing the compass needle to follow the sun, pointing a maximum east of magnetic north in the early morning, reaching a mean-of-day value between 10 and 11 A.M., and pointing a maximum west of north from 1 to 2 P.M., and then returning to a mean-of-day value during the night.

The diurnal variation changes with locality (Fig. 12), and Chapman has found from magnetic observatory data that, whatever the cause, a simple current-system (Fig. 13) will account for the mean daily variation and its geographical distribution over the earth. The system remains fixed with regard to the line earth-sun, and the earth rotates beneath it. In both Northern and Southern Hemispheres there are two sunlit current circulations and two considerably weaker circulations mainly in darkness. A total of 10,000 amperes flows between successive current lines. This current-system corresponds to the annual average of the quiet-day diurnal variation; it therefore only approximately represents conditions on individual days.

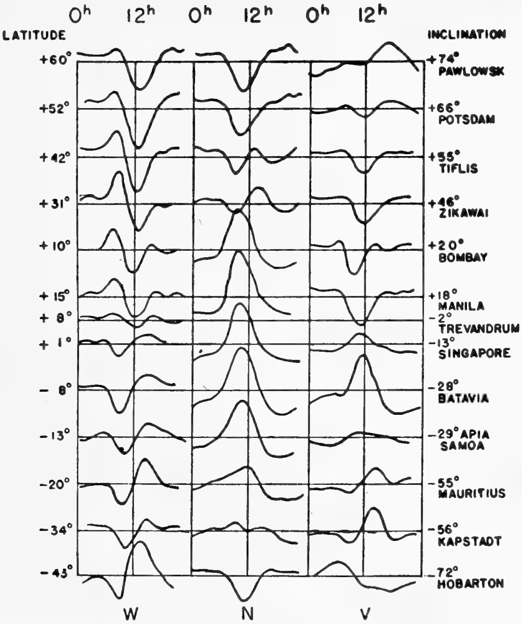


Fig. 12.—Daily variation of terrestrial magnetic elements at equinox. The inclination gives the magnetic latitude. (After Angenheister.)

The probable height and cause of this current-system cannot be uniquely inferred solely from considerations of terrestrial magnetism. However, further nonmagnetic considerations such as the existence of the ionosphere and ultraviolet radiation from the sun may afford a solution. The ionosphere is an electrically conducting portion of the upper atmosphere with regions of maximum ionization at approximately 110 km, 200 km, and 300 km above the earth and known as the E, F_1, and F_2 regions (Fig. 4). These serve to reflect radio waves and presumably to conduct electrical currents responsible for the variations of terrestrial magnetism. Such ionization is due, at least in part, to solar radiations in the far ultraviolet which fail to penetrate to the earth's surface.

A current-system flowing in the earth's atmosphere is likely do so in one of the known ionized regions. A dynamo theory was first suggested by Balfour Stewart and later developed quantitatively by Schuster and Chapman. According to this theory the electric currents are generated by the horizontal motion of ionized air across the lines of force of the earth's permanent magnetic field. The horizontal component of this motion is produced by atmospheric oscillations due to thermal expansion and tidal effects reinforced in part by resonance. Other theories advanced include the drift current theory of Chapman and the diamagnetic theory of Gunn, operative in the long free path region of the ionosphere. Since the electrical conductivity of the atmosphere as given by the quiet-day diurnal variation is much greater than that given by radio echo observations, Appleton believes that conditions are such that the radio reflections do not measure all the ionization.

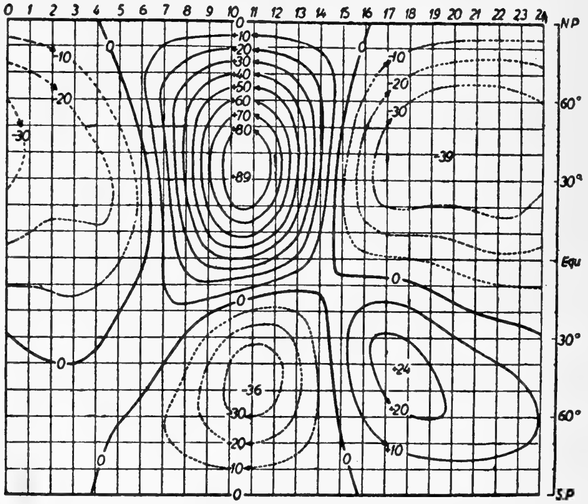


Fig. 13.—Atmospheric systems of electric currents which could produce the solar daily magnetic variation. (After Chapman.)

The solar-flare disturbance, the only definite manifestation of a connection between magnetic changes on the earth and visible manifestations on the sun, gives direct indication of the location of the current-system producing solar diurnal variation. Observations and studies have been made at the National Bureau of Standards and the

Carnegie Institution. At Huancayo all phenomena, solar flare, radio fade-out, and magnetic disturbance, were observed simultaneously on one occasion, giving proof if any were needed that the phenomena are simultaneous. The most striking feature is the radio fade-out, which may last from 15 minutes to 1 hour. It is established that the solar flare is accompanied by an increase of ultraviolet ray emission by the sun, causing increased ionization just below the E layer of the ionosphere. McNish showed that the chief effect is a marked increase in the intensity of the current-system responsible for the quiet-day diurnal variation. This favors the view that the current-system is caused by dynamo action and flows below or at the base of the E region of the atmosphere.

Lunar Diurnal Variation

The lunar diurnal variation is associated with the motion of the moon about the earth. It shows some similarities in general type to the solar variation, but differs in an important respect since it depends on lunar time. Only the dynamo theory is applicable to the lunar diurnal variation. Its amplitude is only one-fifteenth of the solar diurnal variation, although the tidal effect of the moon is twice as great as that of the sun. The explanation is that while the tidal action of the moon is the primary cause of lunar diurnal variation, the moon has no effect in producing ionization. As in the case of the quiet-day solar diurnal variation, the electric current system responsible is external to the earth, and likewise gives rise to induced currents flowing within the earth. Its changes with magnetic activity, more marked than in the case of the solar diurnal variation, suggest that its current-system flows at another level in the atmosphere and possibly in the F region.

MAGNETIC STORMS

Magnetic storms (Fig. 14) are the most striking of all geomagnetic phenomena. These are characterized by large and complex changes in the field occurring on a world-wide basis. They are usually most marked in polar regions and are accompanied by unusual auroral displays, extending to somewhat lower levels than normal, and by earth-current disturbances. Associated with them are also marked ionospheric changes giving rise to widespread interruption of electrical communications. A singularly remarkable feature of the time variations of the storm field is that these are at times closely paralleled by variations in cosmic-ray intensity in low latitudes.

Aurora

The close relation between the aurora and the magnetic storm is held to be due to the fact that the former is the visible manifestation of streams of particles arriving from the sun and likewise causing the storm. The electrically charged particles are required by physical laws to spiral around the lines of force of the earth's magnetic field. The particles ionize the molecules by knocking out a negative electron and energizing the atoms so that they produce the visible radiation seen in aurora. The usual penetration is to within about 110 km above the earth's surface, although this penetration varies with the type of the aurora. The observed upper limit is about 1,000 km in height. The most commonly observed forms of aurora are the homogeneous quiet arcs and the moving curtains or streamers, the latter types often with considerable coloration being especially related to magnetic disturbances.

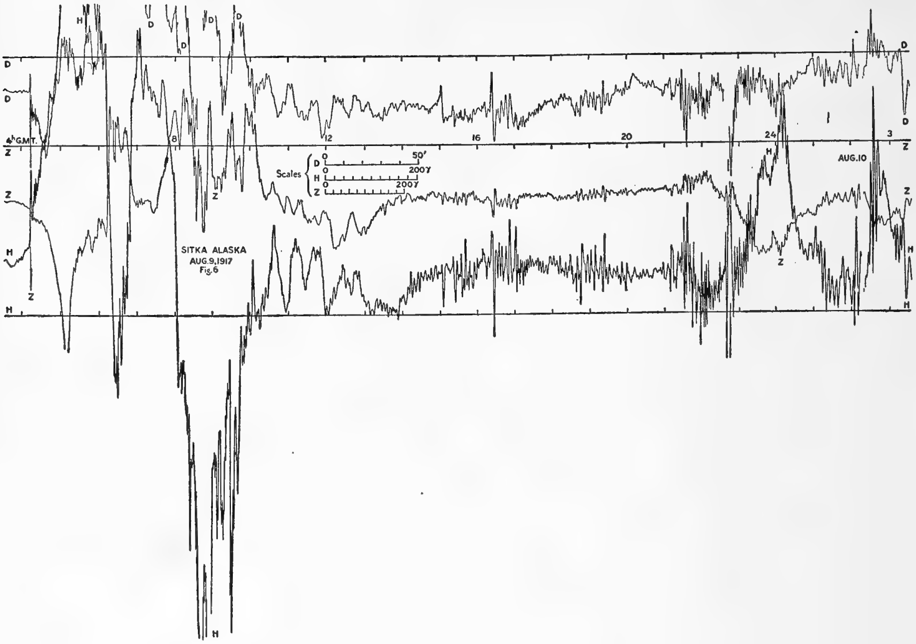


Fig. 14.—Magnetic storm.

Closed curves of equal auroral frequency, known as isochasms, drawn on maps of the polar regions show symmetry relative to the geomagnetic poles. The narrow belts forming the auroral zones, where aurora occur most frequently and with highest intensity, are about 23° of latitude distant from the poles (Fig. 8). In this region also the magnetic changes of storms are particularly intense and highly differentiated locally.

Analysis of Storm Field

Chapman and others have shown that the surface field of storms may be analyzed into three main parts: (1) a part proceeding according to time measured from the commencement of storm, and known as the storm-time variation; (2) a diurnal variation additional to that also present on quiet days, but much greater in intensity and markedly different in type, and known as the disturbance diurnal variation (Fig. 15); and (3) an irregular part, most marked in the polar regions, depending on latitude and in its average features on local time.

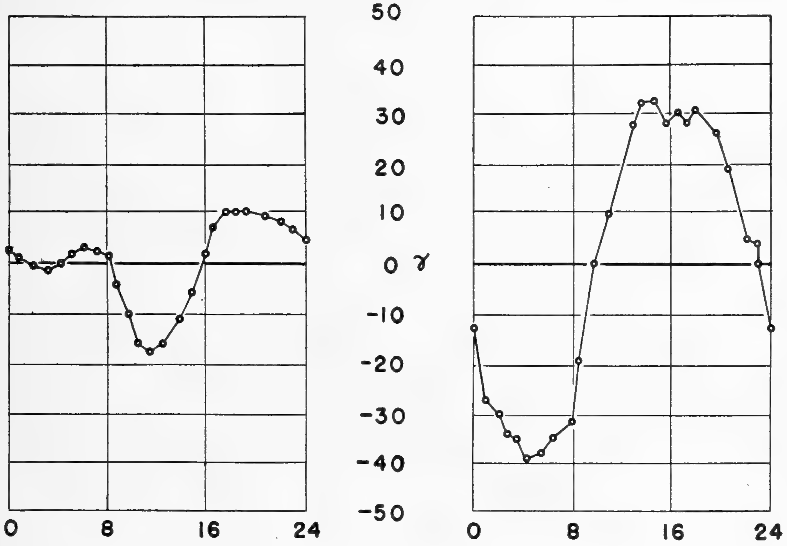


Fig. 15.—Quiet and disturbance daily variation in "H."

A large number of records of storms from many observatories have been analyzed. In low and middle latitudes the storm-time part of horizontal intensity (Fig. 16) rises to a maximum within 1 or 2 hours of the start, then there is a decrease to a value considerably below normal, the minimum being reached in 12 to 30 hours after the start. This is followed by gradual recovery till the normal value is reached. The greater the storm, the more rapid is the development of the phases.

Large storms often have sudden commencements, possibly coincident in time within a few seconds over the entire earth, though the simultaneity has not been proved because of small time scales and uncertain time control.

The geographical distribution of the storm field is somewhat complicated, and it can best be treated by considering the several parts separately. The main characteristic of that part accounting for the storm-time portion is that the electric current flows east-west with greatest intensity near the auroral zone and at the equator. Fig. 17 gives part of the system according to Vestine and Chapman. For the part of the storm depending on local time the currents are very intense in the polar region. In fact, during a great magnetic storm the electric currents flowing along the auroral zone may attain the intensity of about 1,000,000 amperes. It is probable that the height of the current systems is such that they are within the F layer.

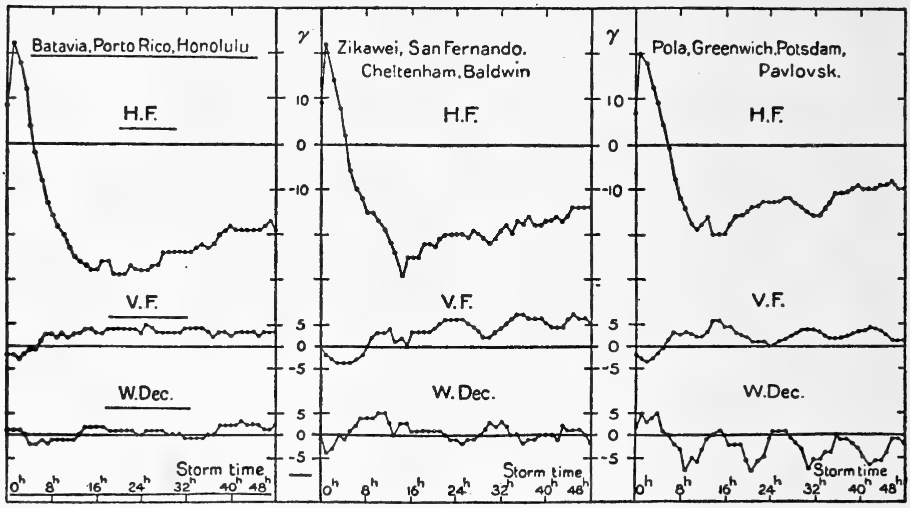


Fig. 16.—Storm-time magnetic disturbance changes in different latitudes.

However, a suggestion not warranted by the magnetic data alone and of doubtful probability seeks to account for the storm-time portion in middle and lower latitudes by a great equatorial ring current at a distance of several earth radii.

The current-systems indicated are undoubtedly too simple, and they have marked changes with time, but they provide a means of representation of the principal magnetic changes in the field during a magnetic storm. Intensive study of the changes in the storm field, and especially of the complete data on magnetic and other phenomena accumulated during the Second Polar Year, gives promise of important advances in the knowledge of the position and nature of the currents and of the origin of magnetic storms. The theory of magnetic storms is in a state of flux at the present time, and no completely successful theory has been proposed, though both corpuscular and ultraviolet theories have been advanced. According to Chapman and Ferraro a magnetic storm is caused by a neutral stream of charged particles which tend to separate in the earth's field, giving rise to the aurora and magnetic storms. The needed current-systems, including the intense currents observed in the auroral zone, may be provided in this way.

Special Forms of Magnetic Disturbance

Magnetic disturbances more moderate in intensity than those of storms frequently occur. Solar flares and associated magnetic effects have been discussed. In polar regions of the earth especially there are often simple, large intensifications (or diminutions) of the earth's field known as bays and lasting from 1 to 5 hours. These tend to occur on a world-wide scale and are more marked near the auroral zone. They may be regarded as due to some distorted and less intense form of the electric current-system of magnetic storms.

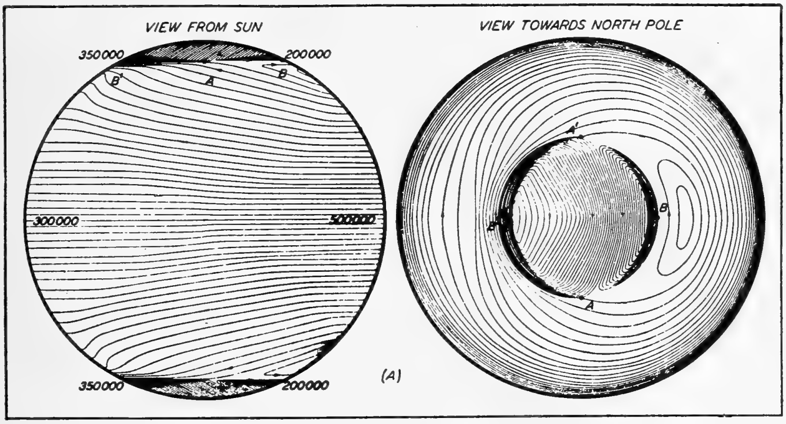


Fig. 17.—Part of current-system accounting for magnetic storms. (Courtesy Journ. Terr. Magn. and Atmos. Electr.)

The earth's field also undergoes at rare intervals highly regular periodic changes known as pulsations. Micropulsations having periods of the order of seconds sometimes occur. These seldom extend over areas of greater extent than a few thousand square kilometers. Another interesting type is the giant pulsation having extremely regular sinusoidal variations with time of period of a few minutes. The causes of these pulsations are not known.

TERRESTRIAL MAGNETISM AND THE SUN

The average amount of magnetic disturbance is closely correlated with the average physical states of the sun associated with mean sun-spot numbers. The variation in the annual average of the amount of the magnetic disturbance on the earth is almost directly proportional to the variation in the mean sun-spot numbers taken for the corresponding year. The connection between individual magnetic storms on the earth and isolated or large sun-spots on the sun is somewhat indefinite, but it appears to be greater in the case of notable magnetic storms than in the case of moderate magnetic storms. Thus, magnetic storms tend to occur more frequently in years when there are many large sun-spots than in years when there are few.

At the beginning of a sun-spot cycle the sun's surface is free from sun-spots; then a few appear in the middle latitudes on both sides of the sun's equator. There is a steady increase in the number; the spots appear nearer the equator and finally disappear at the lowest attained latitudes. Record of the number of sun-spots has been maintained for many years at Zurich, Switzerland, where the final Wolfer numbers are prepared on the basis of reports from a world net of astronomical observatories.

The sun-spot cycle has ranged in the past from 8 to 17 years between maxima. From 1645 to 1715 the scanty records available indicate that there was a long quiet period, which appears to be reflected also in the tree-ring observations, according to Douglass, of the University of Arizona. Though this has been attributed to the interference of two periods of similar amplitude and different length, no periods have been found through analysis which would serve as a basis for accurate prediction. From 1878 to 1932 the average length of the cycle was 11.2 years with 4.6 years from minimum to maximum and 6.6 from maximum to minimum. There is great variation from cycle to cycle.

Most sun-spots occur in latitudes of the sun which have a mean rotation period of 27.3 days, and therefore a continuing disturbance on the sun's surface has approximately the same relation to the earth at this interval.

The natural inference is that if a corpuscular emission from the sun occurs it does so in the form of a stream or jet of electrified particles, this being inferred from the effect of the earth's magnetic field on the stream. Magnetic observations indicate that the jet is not necessarily normal to the sun's surface, since a storm has been observed two days before a spot reached the central meridian. The average arrival is 26 hours after the meridian passage of the spot, corresponding to a speed of 1,100 miles per second. There is a wide range in the time of arrival of the storm after the central meridian passage of the spot. This could be due to differences in the directions of jets on leaving the sun, and to the possibility that the place of emission from the sun is unknown.

Bauer, years ago, pointed out as a result of his analyses that sunspot activity is not a whole measure of solar activity and that the photographic magnetic storm data and variations may intrinsically afford a better measure of solar activity. Bartels has expressed the view that there exist on the sun certain restricted regions, usually but not necessarily in the vicinity of sun-spots, the life of which is usually longer than that of the sun-spots but ordinarily not more than one year. These regions may emit corpuscular streams which cannot be detected by visual, photographic, or spectroheliographic means.

This conception of solar conditions helps to explain the numerous exceptions to normal occurrence, since sun-spots can occur without a magnetic disturbance and disturbances can occur on the earth without a sun-spot being visible. In the former case it is quite possible that a jet goes out but misses the earth. Sudden commencements indicate that the jets have sharply defined boundaries.

Accordingly it may be possible that certain solar problems may find solution through terrestrial magnetism. It may also be that effects of solar disturbance on magnetism and on the ionization of the ionosphere may together form an improved measure of solar activity.

RESUME

We have then the broad picture of an earth and an atmosphere in which the concentric shell is an outstanding feature (Fig. 4). Seismology shows us that the earth consists primarily of a core, a mantle, and a crust. The mantle is perhaps subdivided into several layers, but the surfaces of discontinuity between them are not yet fully defined. The most likely are on the order of 400 and 1,000 km below the surface.

The crust is a fairly definite conception, but its thickness depends to some extent on definition and on the geophysical method used in determining it. From seismology there appear to be several layers under the continents—layers much less in thickness under the Atlantic and Indian Oceans and nonexistent under the Pacific Ocean. Their depths from isostatic considerations have been discussed.

At least 94 percent of the earth's total surface-field magnetism is of internal origin. An accurate knowledge of this field is of great practical as well as theoretical value. The main field undergoes a secular variation. There are also periodic and aperiodic variations in the field appearing in superimposed form. These are caused by electric currents flowing above the ground and give rise to induced currents flowing within the earth. The space distributions of these currents cannot be inferred from magnetic measurements at the earth's surface, but additional nonmagnetic considerations result in determining them with a fair degree of probability. From these variations we deduce information about the earth's interior, the atmosphere, and the sun not forthcoming in any other way.

It is generally accepted that far ultraviolet light is the cause of the ionization which is responsible for diurnal variation, but that magnetic storms are probably associated with slower-traveling emanations from the sun. These are associated with sun-spots, but so indirectly that they appear to rise from disturbed areas on the sun which may or may not have sun-spots.

These are some of the things that have been accomplished, and all those who have taken part can feel pride in their share of the accomplishment. On the other hand, scarcely a start has been made on some of the principal problems. Explanations have not been reached for the magnetic field and its secular change or for the cause of magnetic storms. The immediate cause of deep focus earthquakes is not known, and the ultimate cause of all earthquakes is yet to be discovered, as well as many of the facts about the interior of the earth.

One of the needs is for data at many places, but new observatories should not be added until the interpretation of their records is provided for. One of the great problems in the world-wide studies is to obtain the needed observational data and yet not to do it in such a way as to restrict the interpretation of the results.

There is, therefore, ample challenge in both fields, and the complexity of the problems need not become a bar to progress if the advance is made on a sufficiently broad front and is maintained.

CHEMISTRY.—*The destruction of hydrocyanic acid by prunase and the influence of sugars on the reaction.*[1] James F. Couch and Reinhold R. Briese, U. S. Bureau of Animal Industry.

In the course of investigations being conducted in this laboratory on cyanogenesis in plants, it has become evident that the cyanogenetic enzyme is one of the factors that cause loss of freed HCN. In 1889 Tammann[2] observed that, when dilute solutions of HCN were treated with emulsin, 5 to 50 percent of the HCN is no longer detectable after 24 hours. This observation seems to have been generally forgotten. It may, however, explain the fact reported by Auld[3] that when amygdalin and emulsin react the resulting solution contains less HCN than is equivalent to the dextrose formed during the reaction. In the analysis of cyanogenetic plants such a loss of HCN may be very serious, especially if the HCN content of the plant be small and the enzyme very active.

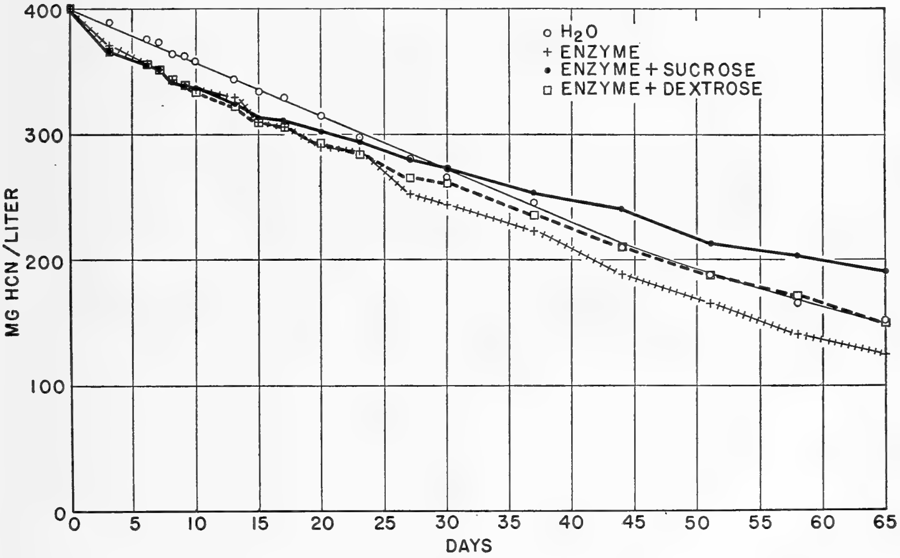


Fig. 1.—Graph of hydrocyanic-acid destruction in water and prunase solutions.

To obtain some quantitative data on this phenomenon a series of experiments was performed. Three liters of a water solution of HCN adjusted to contain 400 mg per liter were prepared. Four 750-cc portions were measured into 1-liter pyrex flasks. One portion was kept as a control. To the second portion was added 10 g of a crude

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[1] Received February 21, 1939.

[2] Zeitschr. physik. Chem. **3**: 25–37. 1889.

[3] Journ. Chem. Soc. T. **93**: 1276–1281. 1908.

prunase preparation obtained from *Prunus serotina.* The preparation was made by extracting the cyanogenetic glucoside from fresh leaves with alcohol and drying the residue at room temperature. The powdered marc so obtained exhibited a strong activity toward crude prunasin. It gave 4.3 mg per 100 g HCN on analysis. The experimental results were corrected for the enzyme HCN.

Since there is some evidence that carbohydrates affect the rate of cyanogenesis in plants, a third portion was treated with 10 g of the enzyme preparation and 5 g of pure dextrose was added. A fourth portion was treated with 5 g of sucrose in addition to 10 g of the enzyme preparation. The four mixtures were stored in a dark place at 25° ± 0.5° and 25-cc portions were withdrawn at intervals for analysis. The mixtures were well shaken several times a day. The results are plotted in Fig. 1. No attempt was made to adjust the mixtures to an optimum *p*H to avoid complication by possibly interfering substances. After 65 days the HCN content of the several lots was: 1, 151; 2, 129; 3, 155; and 4, 196 mg/liter. The curves show that in the presence of prunase HCN disappears more rapidly than in dilute water solution. Dextrose had little effect during the first third of the experiment but neutralized the effect of the prunase to a large extent thereafter. For the first fourth of the experiment sucrose likewise appeared to exert little effect. Then the rate of loss of HCN began to diminish and after the twenty-seventh day the sucrose mixture always contained more HCN than any of the other three.

Although the order of the reaction is not settled, it is of interest to calculate the reaction coefficient. In the absence of definite information to the contrary the monomolecular reaction constant was determined for each series and for the entire period of 65 days. These are stated in the last column of Table 1. The figures indicate the acceleration of the decomposition by prunase, the retardation by sucrose, and a negligible net effect of dextrose.

TABLE 1.—DESTRUCTION OF HYDROCYANIC ACID IN WATER AND PRUNASE SOLUTIONS

Solution	*p*H at end	HCN lost	*k*
		Percent	
Control	3.16	62.2	452×10^{-8}
Enzyme	4.10	67.7	523
Enzyme plus dextrose	3.80	61.2	445
Enzyme plus sucrose	3.82	51.0	320

It was thought that the retarding action of sucrose beginning only some 17 days after the start of the experiment might be due to inversion of the sucrose known to take place in aqueous solutions and that the levulose as formed was actually the retarding compound. To test this hypothesis under actual plant conditions, dextrose, sucrose, and levulose were added to mixtures of ground fresh cyanogenetic plants with water and mercuric chloride as a preservative,[4] which were allowed to macerate for various times at 25°. At the end of four weeks to six months the stored mixtures were analyzed for HCN and compared with a control sample to which sugars had not been added. The latter, however, contained small amounts of their natural carbohydrates, dextrose in *Prunus serotina* and both dextrose and sucrose in the sorghums. The results appear in Table 2. There are no very significant differences between the figures for the various sugars and the controls. Levulose appeared to yield slightly higher results than dextrose or sucrose but did not differ significantly from the controls. The differences observed between these experiments and those reported in Table 1 may be ascribed to the presence of mercuric chloride which combines with the HCN liberated by enzymolysis of the glucoside and indicate that any direct action that carbohydrates may exert in cyanogenetic mixtures is on the freed HCN rather than on the enzymolysis. In the absence of a preservative like mercuric chloride, prunase is capable of accelerating the decomposition of HCN in water solution. Dextrose and sucrose neutralize this action but only after some time has elapsed.

TABLE 2.—EFFECT OF SUGAR ADDED TO CYANOGENETIC PLANT MIXTURES

Date	Plant	Weight of plant	Weight of sugar added	$HgCl_2$	Period	HCN recovered after adding—			
						Dextrose	Sucrose	Levulose	Control
1938		*g*	*g*	*Per cent*	*Weeks*	*mg/100 g*[1]	*mg/100 g*[1]	*mg/100 g*[1]	*mg/100 g*[1]
May 22	Prunus serotina	25	5	2	26	101	100		102
May 22	Prunus serotina	25	5	2	4	98	94		99
June 28	Prunus serotina	25	5	2	4		129		129
July 18	Sorghum vulgare var. hegari	50	2.5	2	8	38	38	40	39
July 25	Sorghum vulgare var. hegari	50	2.5	2	8			35	37
July 27	Sorghum vulgare var. Sharon kafir	50	5	2	8			14	14
July 28	Sorghum vulgare var. hegari	50	5	2	8			28	28
Aug. 22	Sorghum vulgare var. hegari	50	5	3	4	30	33	36	34

[1] mg per 100 g of plant.

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[4] Briese, R. R., and Couch, J. F. Journ. Agr. Res. **57**: 81–107. 1938.

BOTANY.—*New species of* Taphrina *on red maple and on silver maple.*[1]

ANNA E. JENKINS, U. S. Bureau of Plant Industry.

As a result of an investigation of two species of *Taphrina* occurring on North American maples, one on *Acer rubrum* L. and the other on *A. saccharinum* L., the taxonomic history of these two fungi may now be assembled.

THE SPECIES OF TAPHRINA ON RED MAPLE

The species of *Taphrina* on red maple is considered to be new and is named in honor of Prof. John Dearness, whose collections of the fungus in Ontario, Canada (1890–98), are basic to the study. The several specimens gathered in 1898 indicate that the fungus was abundant and destructive in that year (Fig. 1, A and B). His earliest specimen (Dearness 1730), of June 1890, is represented by Ellis and Everhart's Fungi Columbiani 1272 and by North American Fungi 2596, second series. In the order named, these exemplify the two separate descriptions of *Ramularia lethalis* E. & E. (2, 3), as Dearness has explained in letters to the writer. The printed label for North American Fungi 2596, however, bears the date October 1890. Finding the asci in good condition on this specimen bearing an autumn date, the writer brought this to the attention of Dearness; he stated that "October" was erroneous; for the entire gathering was definitely made in June. The *Taphrina* on this material has not hitherto been identified, and the *Ramularia* is regarded as an associated and presumably distinct species, such as the undetermined imperfect that has been observed by the writer on other specimens of this *Taphrina.*

Through the kindness of Professor Bessey, it was possible to examine from the Herbarium of the Michigan State Agricultural College a similar specimen bearing the label:

Ex herb. Agricultural College, Mich.
49 *Gloeosporium aceris* Cooke
On *Acer rubrum*
N. of College 1890

The name "*Gloeosporium aceris* Cooke" (1) is here in the handwriting

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[1] This account is part of a paper read December 30, 1938, before the Joint Session of the Mycological Society of America and the American Phytopathological Society at the 103d meeting of the A.A.A.S., Richmond, Va. During July and August 1938, the writer was a guest worker at the Department of Botany, University of Wisconsin, and studied many of the specimens herein discussed. Grateful appreciation is expressed to the chairman of this department, Prof. E. M. Gilbert, for privileges and courtesies extended; to Drs. H. D. House, D. H. Linder, I. E. Melhus, and F. J. Seaver for permission to study material in their charge; and to Profs. E. A. Bessey, G. W. Carver, J. Dearness, E. B. Mains, H. M. Fitzpatrick, and others for correspondence, contribution of specimens, and access to certain other specimens. Received February 24, 1939.

of Beal, according to Bessey. On the large discolorations of the leaves of this species the writer found a species of *Taphrina* identical with that which Dearness collected in Ontario the same year.

Other early gatherings of this species of *Taphrina* also available are as follows: Alabama, Notasulga and Tuskegee, Apr. 29, 1897, G. W. Carver 154; Michigan, near Lansing, June 2, 1897, C. F. Wheeler; North Carolina, May 1901, comm. F. Sherman, Jr. Under his generic determination of "*Exoascus?*" Carver sent part of the first specimen just cited to Ellis, who labeled it doubtfully *Gloeosporium decolorans* E. & E., a species previously described (4) on red-maple leaves from Ontario collected by Dearness. The Wheeler specimen from Michigan, referred to immediately above, consists of about 25 well-preserved leaves on which the dark discolorations, often along the main veins, contrast strongly with the remaining green areas (Fig. 1, C). This specimen, heretofore unidentified, has remained practically lost, the only available label being what is evidently Wheeler's field label, giving only locality ("Woods S. of C. and G. T. R. R." = Southeast of Lansing), date, and his initials as collector (Fig. 2, A). The handwriting on this label and also on that shown in Fig. 2, B, referred to later, has been verified by Prof. Bessey as almost certainly Wheeler's, except for the initials on the second label, which he states are not written in the usual manner shown in Fig. 2, B. It is of particular interest that the third specimen mentioned above was sent by the North Carolina State Commission for Controlling Crop Pests to the U. S. Department of Agriculture for identification of the fungus causing a severe leaf disease (Fig. 1, D, E). The fungus was studied by Mrs. Flora W. Patterson as a possible species of *Taphrina,* although her records indicate that she found no asci.

In 1923, the writer collected a fresh specimen of a destructive fungus on red-maple leaves at Walton, Delaware County, N. Y., and identified it as belonging to the genus *Taphrina.* This specimen, together with that from North Carolina, was subsequently reported by the writer (5) as a new species of this genus, but without diagnosis or name. Later gatherings of the fungus in New York and Pennsylvania have been made (Fig. 3, A–G), and these will be cited following the technical description.

In size the asci of this species (Fig. 4, A) are much smaller than those of *T. lethifera* (Pk.) Sacc. on mountain maple (*Acer spicatum* Lam.) illustrated elsewhere (6, Fig. 2, A). As compared with the asci

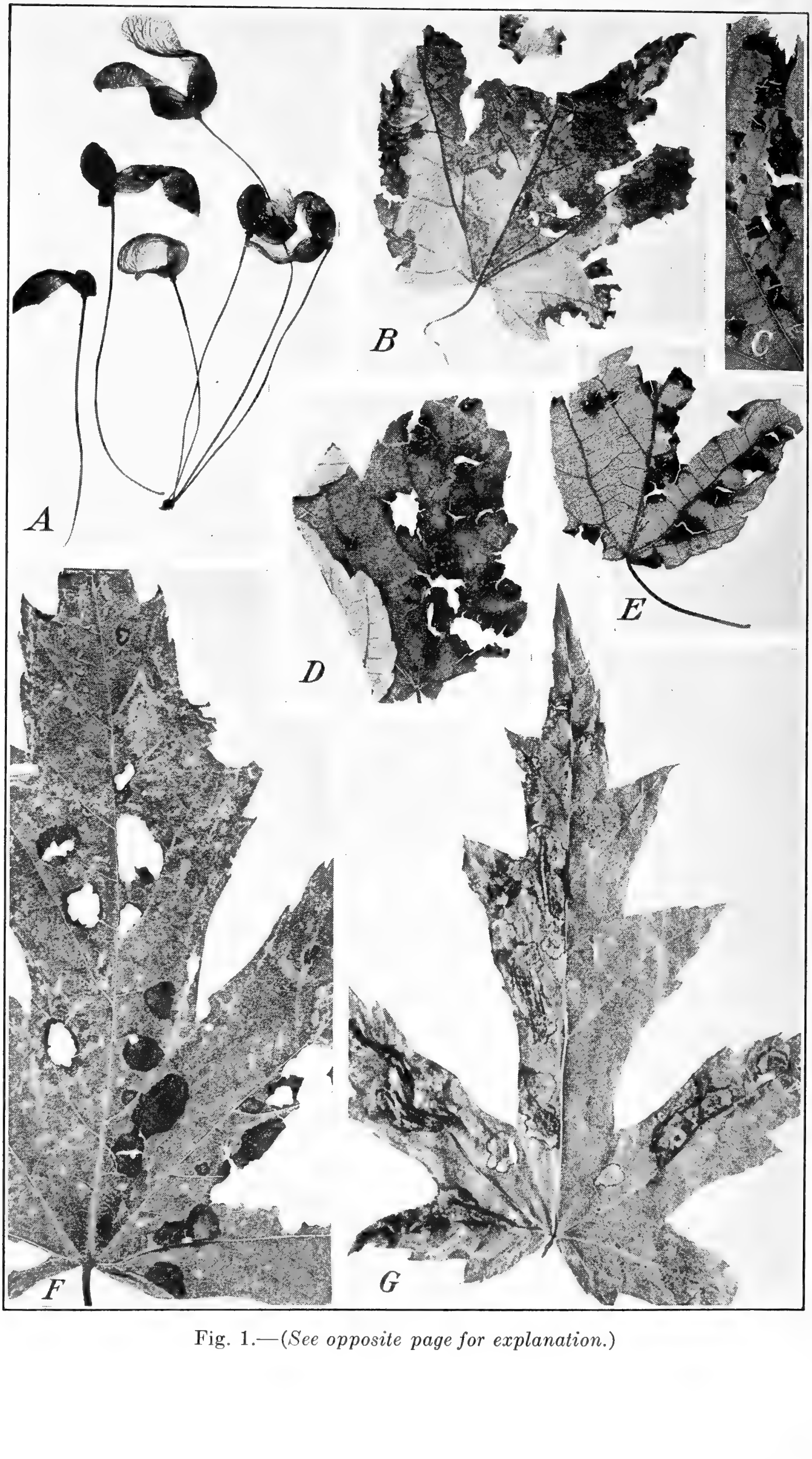
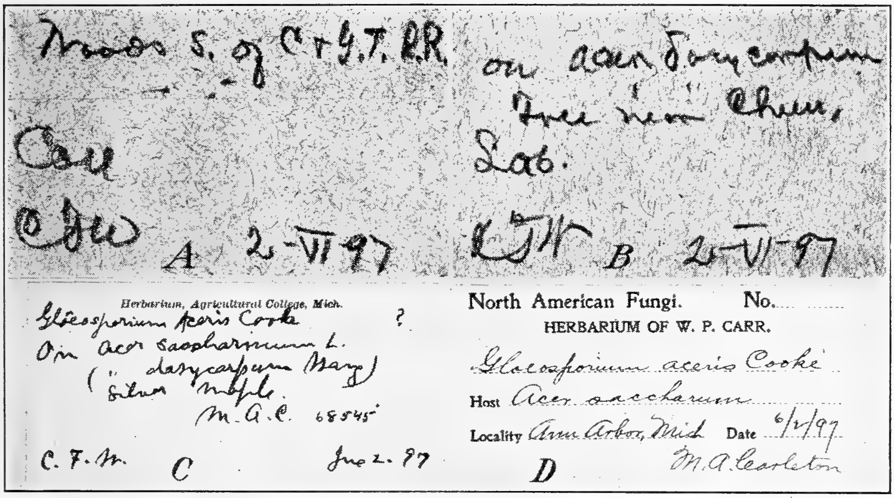


Fig. 1.—(*See opposite page for explanation.*)



Woods S. of C+G.T. R.R.
Carr
CFW 2-VI-97

on acer dasycarpum
Tree near Chem.
Lab.
CFW 2-VI-97

Herbarium, Agricultural College, Mich.
Gloeosporium aceris Cooke ?
On Acer saccharinum L.
(" dasycarpum Marsh)
(silver maple.
M.A.C. 68545
C. F. W. Jne 2. 97

North American Fungi. No.
HERBARIUM OF W. P. CARR.
Gloeosporium aceris Cooke
Host Acer saccharum
Locality Ann Arbor, Mich Date 6/2/97
M. A. Carleton

Fig. 2.—A and B: Wheeler's original labels accompanying specimens of diseased red (A) and silver (B) maple leaves he gathered on June 2, 1897. C: In Beal's handwriting, herbarium label for the silver-maple leaves; herbarium number 68545 (Myc. Coll. B.P.I.) added by the present writer. D: Label for the leaves of this specimen from the Carr Herbarium. Photographs of original labels by Eugene Herrling.

of *T. sacchari* Jenkins (Fig. 4, C[2]), recently described (7) on sugar maple (*A. saccharum* Marsh.) the asci of the red-maple species are generally the larger. The form of the asci of these three species may be compared in the illustrations cited.

This species, designated as *Taphrina dearnessii*, is described as follows:

Taphrina dearnessii n. sp.

Spots located anywhere on the leaf, although often marginal or scattered along the main veins and more or less delimited by them, sometimes causing a wrinkling of young leaves, more or less circular or angular, of various sizes, deciduous, discolorations sometimes covering entire area between main veins or involving practically entire leaf, on dry specimens often "bister" (9) to "blackish brown"; at center sometimes "cinnamon" and somewhat translucent; affected samarae discolored entirely or in part; asci numerous, covering discolored areas on samarae or hypophyllous, rarely epiphyllous,

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[2] In a previous article (8) a citation was made to an unpublished paper ("A Species of *Taphrina* on Red Maple") containing an illustration (photomicrograph of asci and ascospores) of *Taphrina sacchari*. In the present paper, containing part of the data in the unpublished article, Fig. 4, C is adapted from the unpublished photomicrograph.

Fig. 1.—A–E: *Taphrina dearnessii* on samarae (A) and leaves of red maple (B–E) from (A) London, Ontario, June 1898, J. Dearness (E. and E. Fungi Columbiani 1348); (B) McGillivray, May 31, 1898, J. Dearness; (C) vicinity of Lansing, Mich., June 2, 1897, C. F. Wheeler; (D and E) North Carolina, 1901. F and G: *T. carveri* on silver-maple leaves from (F) Lansing, Mich., June 2, 1897, C. F. Wheeler, and from (G) Tuskegee, Ala., Apr. 30, 1897, G. W. Carver. B and D, lower leaf surface, others upper leaf surface. All ×1. Photographs by Eugene Herrling (A and C) and M. L. F. Foubert (B and D–G).

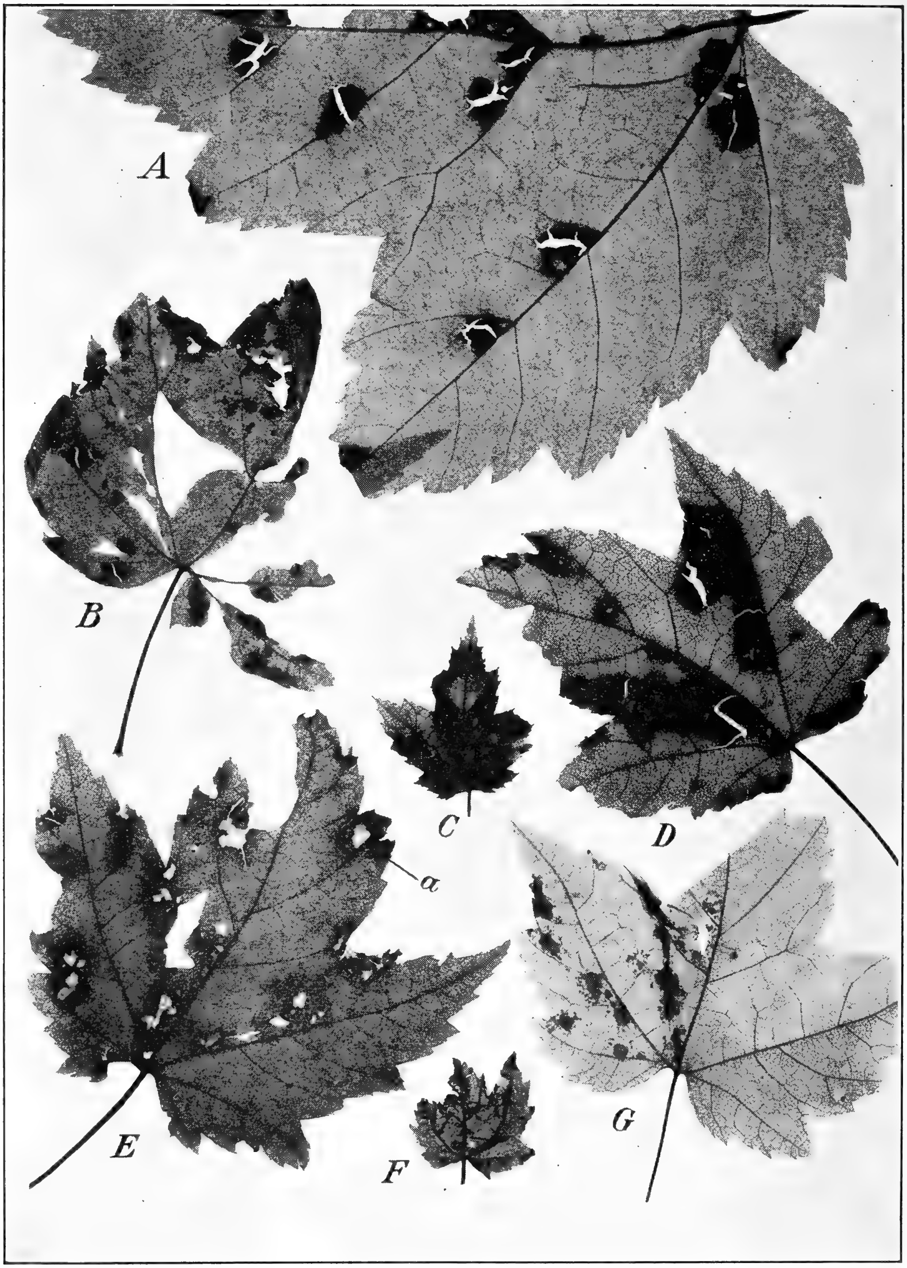

Fig. 3.—*Taphrina dearnessii* on red-maple leaves from (A) La Porte, Pa., 1933, L. O. Overholts; (B–F) Walton, N. Y., June 16, 1929, A. E. Jenkins, type; and (G) Lewis Co., N. Y., 1927, D. S. Welch and C. H. Cunningham; A and C, upper leaf surface, others lower surface. E, *a*, light or cinnamon color of lesion. All × 1. Photograph by Eugene Herrling.

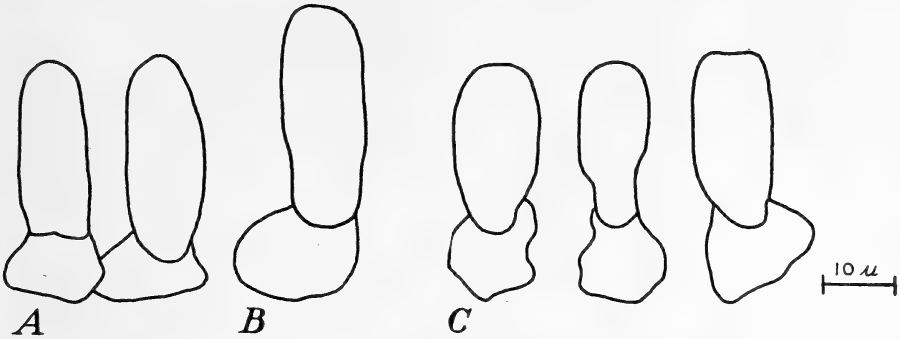

Fig. 4.—A: Asci of *Taphrina dearnessii* from type specimen, represented in Fig. 2, B–F. B: Ascus of *T. carveri* from type specimen, represented in Fig. 1, F. C: Asci of *T. sacchari* from specimens from Wisconsin, June 1904, illustrated elsewhere (8).

cylindrical to slightly clavate, at apex rounded or truncate 17–29μ high by 8–13μ wide, often 21–29μ by 10–11μ, sometimes sunken in the stalk cell as much as 3.5μ, containing 8 spores at first; stalk cell rounded, flattened or slightly pointed at base, rarely moderately lobed, resting on the epidermis, 6–12μ high by 10–18μ wide; spores globose to elliptical, 2.8–5.6μ by 3–3.5μ, budding in the ascus.

Maculas circulas vel angulares efficiens; asci hypophylli, raro epiphylli, cylindrici usque clavati 17–29μ × 8–13μ plerumque 21–29μ × 10–11μ; cellulae basilares 6–12μ × 10–18μ; subglobosa vel elliptica, sporidia 2.8–5.6μ × 2.8–3.5μ.

Distribution and specimens examined.—On *Acer rubrum* L., causing "leaf blister of red maple."

ALABAMA: Notasulga (about 12 miles from Tuskegee) [NY and W][3] and Tuskegee [C–IS and W], Macon Co., Apr. 29, 1897, *G. W. Carver* 154.

MICHIGAN: North of College, Lansing, Ingham Co., 1890 (Ex Herbarium Michigan State Agricultural College 49) [MS]; southeast of Lansing, June 2, 1897, *C. F. Wheeler* [MS and W] (Fig. 1, C).

NEW YORK: Walton (Mountain Home Farm), Delaware Co., Aug. 1, 1923, *A. E. Jenkins;* July 10, 1924, *F. A. Jenkins;* July 20, 1924, *A. E. Jenkins;* June 20, 1925, *E. J. Hoose;* July 22, 1927, and June 16, Type 69297 [W][4] (Fig. 3, B–F), and June 17, 1929; Lewis Co., Fisher Tract, Number 4, June 21, 1927, *D. S. Welch* and *G. H. Cunningham* (Fig. 3, G); vicinity of

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[3] In this paper herbaria in which are filed specimens examined during this study are indicated as follows:

C–IS Carver Collection, Herbarium of the Iowa State College, Ames, Iowa.
D Dearness Herbarium, London, Ontario.
F Farlow Cryptogamic Herbarium, Harvard University, Cambridge, Mass.
MS Herbarium of the Michigan State Agricultural College, Lansing, Mich.
NY New York Botanical Garden.
P Peck Herbarium, N. Y. State Museum, Albany, N. Y.
UW Herbarium of the University of Wisconsin, Madison, Wis.
W Mycological Collections of the U. S. Bureau of Plant Industry, Washington, D. C.

Where no symbol is given the specimen is in the Mycological Collections; the symbol "W" is only employed when the specimen cited also exists in another herbarium.

[4] The specimens designated as types are chosen because they are thoroughly representative of the species, although neither was gathered by the person in whose honor it is named.

Ithaca, Tompkins Co., July 9, 1927, *A. E. Jenkins;* June 11, 1937, *W. W. Ray* 350 and 351; Oswegatchie, St. Lawrence Co., July 12, 1937, *D. S. Welch* and *W. L. White.*

NORTH CAROLINA: May 1901, comm. *F. Sherman, Jr.* (Fig. 1, D and E).

ONTARIO: June 1890, *J. Dearness* (Ellis and Everhart Fungi Columbiani 1272 [D[5] and NY] and North American Fungi 2596, second series [D[5] and W]; May 23 (about 8 miles west of London, Middlesex Co., and May 24, 1898, *J. Dearness,* both specimens on samarae [D and W]; June 1898, *J. Dearness* (Ellis and Everhart Fungi Columbiani 1348, issued as *Gloeosporium decolorans* E. and E. and containing samarae (Fig. 1, A) and leaves [W]); McGillivray, Middlesex Co., May 31, 1898, *J. Dearness* [D and W] (Fig. 1, B).

PENNSYLVANIA: Shingleton, Centre Co., *L. O. Overholts* 18149 and *W. A. Campbell,* La Porte, Sullivan Co., June 14, 1935, *L. O. Overholts* 18148 (Fig. 2, A).

THE SPECIES OF TAPHRINA ON SILVER MAPLE

A species of *Taphrina* on silver maple (*Acer saccharinum*) (often called white maple) was collected in Ontario, at Lucan, by Dearness (Dearness 2144) on July 17, 1893. He sent a specimen to Prof. C. H. Peck, at Albany, N. Y., where it was first seen by the writer in 1931. Peck labeled the specimen "*Gloeosporium maculosum,*" but a description was never published. From the fact that Peck intended to describe the fungus as a *Gloeosporium* it is clear that he did not realize that a species of *Taphrina* was concerned.

Four years after Dearness collected this species in Canada on April 30, 1897, Carver collected it on severely diseased leaves of silver maple at the Tuskegee Institute (Fig. 1, G). Having discovered the *Taphrina,* he sent a specimen (Carver 153) bearing his generic determination to Ellis, but there is no indication that Ellis ever studied it, and Carver has recently written that he finds no mention of it in Ellis's correspondence with him. Dr. Carver has also written (Feb. 20, 1939) that the young trees from which he collected this species of *Taphrina* were said to have been sent from a nursery in Iowa.

On June 2, 1897, Wheeler also made an ample collection of diseased leaves from a tree of silver maple growing on the campus of the College at Lansing, Mich. (Fig. 1, F). Unfortunately, until the present, this specimen has been labeled "*Gloeosporium aceris* Cooke?" The herbarium label is in the handwriting of Beal (Fig. 2, B), although Wheeler's original label, "On *Acer dasycarpum,* tree near Chem. Lab., C.F.W. 2-VI-97" (Fig. 2, C), is at hand. Years later, after studying this specimen, the writer (5) reported it as a new species of *Taphrina,* although without name or description. The specimen

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[5] The specimen in the Dearness Herbarium is here part of the original gathering retained by Dearness and not issued as a part of this exsiccatum.

studied at that time was unfiled in the Mycological Collections of the Bureau of Plant Industry, but it was later learned that part of the gathering with the same label by Beal is also in the Herbarium of the Michigan State Agricultural College. During the summer of 1938 the writer found in the Herbarium of the University of Wisconsin a packet containing a few diseased silver-maple leaves, which were subsequently traced as having come from the original gathering by Wheeler in the Mycological Collections. Although prepared on the basis of Beal's label, the label on the packet at Wisconsin showed certain misinterpretations. For the "M.A.C." of Beal's label, signifying the "Michigan Agricultural College" at Lansing, was here substituted for the actual collector as "M. A. Carleton," and "Ann Arbor" was introduced as the place of collection. Nevertheless, upon finding this specimen labeled as illustrated, the writer was convinced from the first that it was part of Wheeler's gathering.

Since Carver appears to have been the first to observe the asci of this species of *Taphrina* (Fig. 4, B), it seems particularly fitting that it be named in his honor. It is therefore named *T. carveri*, and is described as follows:

Taphrina carveri n. sp.

Discolored areas on leaves sometimes somewhat wrinkled, scattered or occasionally confined to one part of the blade, consisting of circular, elliptical or irregular spots up to 25 or more on a single leaf and up to 3 by 1 cm in diameter, or of more elongated areas situated between the main veins and reaching the leaf margins, on dry herbarium specimens "sepia" above, "isabella color" and "light brownish olive" below, to "blackish brown" on both surfaces, sometimes upper surface covered with delicate bloom; asci amphigenous, more commonly hypophyllous, usually cylindrical, at apex rounded or truncate, 23–35μ high by 7.8–16.8μ wide, often 26–30μ by 9–15μ, with spores (apparently 8 at first) and many budded conidia; stalk cell rounded, flattened or irregular, sometimes slightly pointed at base, occasionally moderately lobed, resting on the epidermis, 4–15μ high by 10–22μ wide; spores subglobose or elliptical 4–7μ in diameter; budded conidia variable, spherical to oblong-elliptical, latter reaching 7 by 3μ.

Maculas circulares, ellipticas vel irregulares, usque 3 cm diam. efficiens; asci amphigeni, saepius hypophylli, plerumque cylindrici, 23–35×7.8–16.8μ; cellulae basilares 4–15μ×10–22μ; sporae subglobosae vel ellipticae, 4–7μ in diam.; conidia variabilia, spherica usque oblongo-elliptica, usque 7×3μ.

Distribution and specimens examined.—On *Acer saccharinum* L., causing "leaf blister of silver maple."

ONTARIO: Lucan, July 17, 1893, *J. Dearness* 2144 [D, P, and W].

ALABAMA: Tuskegee, Macon Co., Apr. 30, 1897, *G. W. Carver* 153 [F, C–IS, and W] (Fig. 1, G).

MICHIGAN: Lansing, Ingham Co., June 2, 1897, *C. F. Wheeler* [MS, W, and UW], Type 68545 [W][4]. (Fig. 1, F).

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BOTANICAL SOCIETY

286TH MEETING

The 286th regular meeting was held in the assembly hall of the Cosmos Club, January 4, 1938, President G. F. Gravatt presiding; attendance 88. Albina F. Musil, Harriet Cull, and C. Eugene Larsen were elected to membership.

Notes and Reviews.—C. R. Ball called attention to a new book, *Botanical studies of the Uinta Basin of Utah and Colorado,* by Edward H. Graham, published in the Annals of the Carnegie Museum.

Program.—Reports of the papers presented at the meeting of the American Association for the Advancement of Science at Indianapolis, Ind., were given by: A. G. Johnson on pathology; E. E. Clayton on tobacco diseases; E. C. Johnston on physiology; Howard Johnson on forage crop diseases; Eubanks Carsner on entomology; George M. Darrow on small fruits diseases; J. B. Demaree on fruit and vegetable diseases.

287TH MEETING

The 287th meeting was held in the assembly hall of the Cosmos Club, February 1, 1938, President Gravatt presiding; attendance 125. Vernon T. Stoutmeyer, E. A. Hollowell, H. C. Hyland, Richard P. White, and F. D. Fromme were elected to membership.

Program.—F. D. Richey: *Collecting corn ornaments.*

A. C. Foster: *The effect of environment on the metabolism and blossom-end rot disease in tomato.* Extensive data were collected from 8 crops of tomatoes grown under controlled greenhouse conditions involving differences in soil moisture, soil nutrition, air temperature, light duration, and the interrelation and interaction of these component factors, any one of which may become a limiting factor to normal plant growth, and metabolic and respiratory activity, and thereby interfere with the normal development of tomato fruit.

The data suggest that the factors affecting the development of blossom-end rot are far more complex than is usually recognized: (1) High carbohydrate plants had the largest percent of the disease when grown under short day period; (2) high nitrogen plants were very susceptible to the disease under long day conditions; (3) soil moisture at 70 percent of saturation was optimum for vegetative growth and also optimum for the disease; (4) superphosphate had a marked effect in reducing the incidence of the disease; (5) the rate of transpiration or water requirement apparently had no relation to the disease as it appeared under both extremes when other conditions were favorable; (6) one component factor of the environmental complex may become a limiting factor to the normal activity of all others and promote conditions favorable to causing the disease.

288TH MEETING

The 288th regular meeting was held in the assembly hall of the Cosmos Club, March 1, 1938, President GRAVATT presiding; attendance 110. C. W. EMMONS was elected to membership.

Notes and Reviews.—GEORGE DARROW called attention to the following articles: *Physiological genetics,* by Robert Goldsmith, Journal of Heredity, vol. 20, 1938; *Physiologic curve of response by seeds, growing plants, cuttings and lower plant forms,* by N. H. Grace, National Canadian Research Journal, Nov. 1937; *Aneurin and the rooting of cuttings,* by Went, Bonner and Warner, Science, Feb. 18, 1938.

Program.—W. A. ARCHER: *Plant exploration in Latin America.* It was pointed out that the chief disadvantages of travel in tropical countries were the monotonous diet and the numerous insect pests, especially those that transmit infectious diseases. The more striking of the plant finds were some giant peanuts from the Matto Grosso as well as the tiny seed of the wild peanut. Of interest also was the recovery of some long-lost tobacco strains in Costa Rica from volunteer plants that had sprung up from seed lying dormant for a generation under the floors of houses. In that country often when an old house is demolished by the owner or by earthquake the tobacco seeds germinate and produce plants.

IRVING T. HAIG: *Silvicultural history of the western white-pine type.* The creation of the United States Forest Service in 1905 marked the first formal step toward the practice of silviculture over extensive land areas in the Western States. The formulation of satisfactory methods of cutting in the complex and variable forests characterizing the western white-pine type in the Northern Rocky Mountain region was obviously a task of considerable difficulty, particularly as at that time little or nothing was known about the silvical habits or requirements of the associated tree species other than their names, botanical description, and general occurrence.

As a result of research, plus accumulated experience, the system of cutting on national forests, starting out with a scattered seed-tree system, swung through a complete cycle and back to this same system in about one decade, some five other systems of cutting having been employed. Present trends, mainly influenced by economic conditions, are toward a crude two-cut shelterwood system.

289TH MEETING

The annual banquet and 289th regular meeting was held in the ballroom of the Kennedy-Warren Hotel, April 5, 1938; attendance 80. Professor Whetzel of Cornell University was a guest of honor at the dinner.

Program.—WALTER C. LOWDERMILK gave an illustrated lecture on *Soil conservation and the California floods.*

SPECIAL MEETING

A special meeting was held in the auditorium of the U. S. Department of

Agriculture, April 19, 1938, at which PHILIP R. WHITE of the Rockefeller Institute spoke on *Root cultures and root pressure.* The history of theory concerning the mechanism of sap movement, a subject of investigation and controversy for the past 350 years, was briefly outlined. The "cohesion theory" of Dixon and Joly and of Askenazy has in the past 30 years largely superseded all others. This theory, however, possesses certain weaknesses and is incapable of explaining water movement under conditions of saturated atmosphere, as in the rain forests of the tropics.

Experiments with growing excised tomato roots have shown that such roots regularly maintain a continuous, rhythmic, basipetal flow of water in quantity and under pressures adequate to satisfy the needs of the tallest trees under conditions unsuitable for the functioning of the cohesion scheme. Secretion pressures of at least 6 atm. were recorded. This process is dependent on the activity of living cells. The two processes—secretion flow and transpiration flow—supplement one another and together seem capable of providing a complete and adequate explanation of sap movement. ALICE M. ANDERSEN, *Secretary.*

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JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. 29 JUNE 15, 1939 No. 6

PHYSICS.—*Recent advances in the investigation of cosmic rays.*[1]

THOMAS H. JOHNSON, Bartol Research Foundation, Swarthmore, Pa., and research associate of the Carnegie Institution of Washington. (Communicated by JOHN A. FLEMING.)

Perhaps the greatest heritage we have from the early men of science, of whom Joseph Henry was an outstanding example, is the faith they have given us that it is worth while investigating any unknown natural phenomenon simply because it is unknown. Their experience has proved that the investigation of the smallest and apparently the least significant effects sometimes yields a rich reward. The investigation of the cosmic radiation began with a humble phenomenon that might have turned out to be a mere leakage across an insulating plug, and although we are not sure yet just what the rewards of the investigation in the material sense may be, we may be justly certain that the discoveries will have great human value, even if they result in nothing more than the filling in of the gaps of ignorance in our more complete knowledge of the properties of high energy radiations.

The story of the discovery of the cosmic radiation is well known and need not be repeated in great detail. It will be recalled that in the years 1900 to 1910 the residual ionization in a gas-filled vessel, that part left over after all the known radiations had been eliminated, had proved remarkably stubborn, in spite of all attempts to change or stop it. If this ionization were caused by radiation originating in the earth, changes of location and of elevation should have had some effect; but experiments in which the instruments were taken out over lakes and up in towers showed that the radiation remained always in about the same amount, a small amount, to be sure, but one that with improving technique became more and more certain of existence. Finally, in 1913, Hess improved upon some earlier experiments of Gockel and carried an instrument up to about 5,000 meters above sea level in a free balloon. As he ascended he found a small increase in the ionization but an increase that now seemed to be quite definite. He interpreted

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[1] The Ninth Joseph Henry Lecture of the Philosophical Society of Washington, delivered on March 25, 1939. Received March 25, 1939.

his results in a statement which I translate from the German as follows: "The results of these investigations seem most readily to be explained by the assumption that a radiation of very great penetrating power falls upon our atmosphere from above, and even in the lower levels it produces a part of the ionization observed in closed vessels." This was the first definite suggestion based upon experimental findings of the existence of a cosmic penetrating radiation. Subsequent experiments by Kolhorster and Millikan confirmed Hess's contention, and the horizon was cleared for the next step in the investigation.

Were these rays found by Hess being generated in the highest layers of the atmosphere? Were they coming from the sun or the planets? Or were they emanating from some more distant part of the cosmos in remote spiral nebulae or in intergalactic space? In looking for an answer possible variations of the cosmic-ray intensity with time and with position on the earth were sought, to find if there were preferential directions in space from which the intensity was greater or less. To all these attempts the answer was always the same. The radiation was extremely constant as if it were proceeding from sources evenly distributed throughout the universe. Millikan, for example, found no change of intensity when the Milky Way passed below the horizon, and a number of experimenters found no variations from night to day or with the time of the year that they could be sure of with the technique then in use.

Still others in this early period were concerned with finding the energy of the cosmic-ray quanta, and for this purpose the absorption of the radiation in the atmosphere and in various other substances was studied. Results were interpreted on the assumption that the cosmic rays were like gamma rays, and absorption laws suitable for X-rays and gamma rays were extrapolated to the higher energies of the cosmic radiation. These laws when applied to rays of given energy implied an exponential variation of intensity with depth, the exponent depending on the energy, and the observed departures from an exponential law in the experimental curve were taken to be an indication that several different energies were present in the cosmic-ray spectrum. To find these energies the intensity-depth curve was resolved into a number of exponential curves (Fig. 1), each of which was supposed to represent one component of the primary radiation. Having found the energies in this way it was tempting for one to speculate as to what processes might have produced rays of these energies. Perhaps the cosmic-ray spectrum could reveal facts about the universe just as the atomic spectrum had led to a thorough understanding of the structure of the atom. A most alluring interpretation of the results was suggested by Millikan in his famous atom-building hypothesis, which drew attention to the agreement between the cosmic-ray energies deduced from the intensity-depth curve and the energy equivalent of the mass deficiency of some of the common elements as compared with the masses of their elemental particles. In the cosmic radiation, it was suggested, was living evidence of the creation of matter in the more complex forms from simple hydrogen.

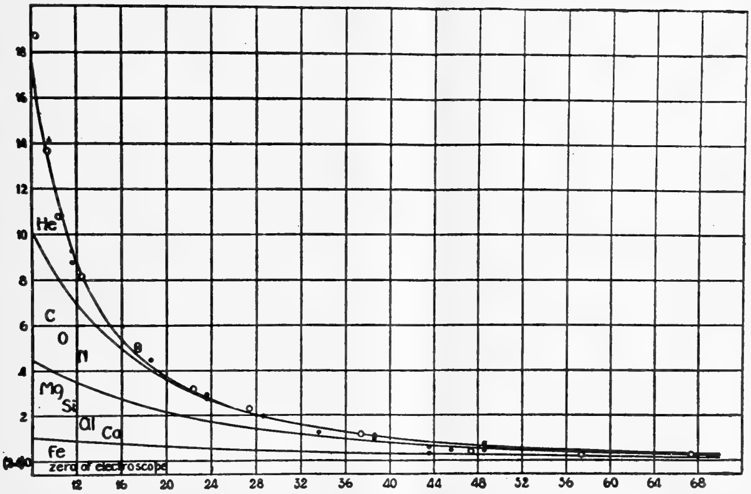

Fig. 1.—The intensity of the cosmic radiation is plotted as a function of depth below the top of the atmosphere expressed in terms of the equivalent number of meters of water. The resolution of the experimental curve into four exponential curves is also shown to illustrate how, in the earlier period of the investigation, the energy of the primary rays was "derived" from the experimental data. These exponential curves corresponded to energies equivalent to the mass deficiencies of the elements indicated. (From Millikan and Cameron.)

In retrospect this hypothesis was important not so much for its own sake as for the stimulus it gave to both believers and disbelievers in the pursuance of other investigations leading to new discoveries, discoveries that overthrew the original hypothesis and showed that the cosmic rays were not gamma-ray quanta but were in fact electrically charged particles. Up to that time it had been quite generally assumed that the primary rays entering the atmosphere from above were absorbed by interaction with electrons of the atoms in the atmosphere. The theory of this type of interaction when applied to the observed curve led to the conclusion that the primary rays had energies ranging from 30 to 1,000 million volts. The ionization, according to this theory, would have been produced by the recoiling electrons, and these were supposed to be much less penetrating than the primary gamma radiation. In 1927 Skobelzyn found the tracks of rays in his cloud chamber whose energies were at least as great as had been expected from the recoil hypothesis; but in 1929 Bothe and Kolhorster showed that these corpuscles were themselves as penetrating as the total cosmic radiation, and it was no longer necessary to consider the ionizing rays as secondaries to a more penetrating non-ionizing radiation, such as the gamma rays. The ionizing corpuscles might be the primary cosmic rays themselves. This was a new point of view suggesting new things to look for.

If the primary rays were electrically charged corpuscles, the earth's field should prevent those of lower energies from reaching the earth's surface at the Equator where the horizontal component of the field is the strongest. Experiments by Clay had already indicated such an equatorial deficiency, and the effect was soon confirmed and more accurately measured during the extensive geographic surveys conducted by Compton, Millikan, and numerous others (Fig. 2).

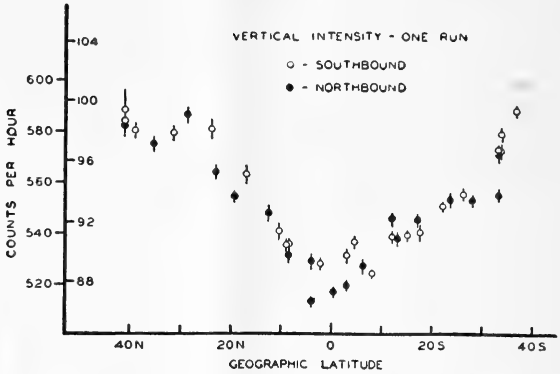

Fig. 2.—The intensity of the cosmic radiation in the vertical direction is plotted against the latitude. The lower intensity near the Equator is due to the exclusion of the rays of lower energies from the equatorial belt by the earth's magnetic field. (From Johnson and Read.)

In producing this equatorial deficiency the earth is acting as a huge magnetic spectrograph, resolving in effect the primary rays into a momentum spectrum. From a closer study of the phenomenon it soon became possible to determine how the primary rays were distributed in energy. What the earth's field actually does is to exclude rays whose energies are less than a certain critical value from an equatorial zone bounded on the north and south by parallels of equal magnetic latitude. The mathematical analysis for determining the critical energies as a function of the latitude had been started many years ago by Störmer, but the solutions of the equations could not be expressed in terms of known functions and his progress was slow. It remained for Lemaître and Vallarta, with the help of the Bush differential analyzer, to complete the work, and now we know the lowest cosmic-ray energies accessible to each latitude. For example, rays must have energies in excess of 18 billion volts if they are to reach the earth at the Equator; 6 billion volts are required for the latitude of 40°. These energies were from 10 to 1,000 times more than those considered according to the older point of view.

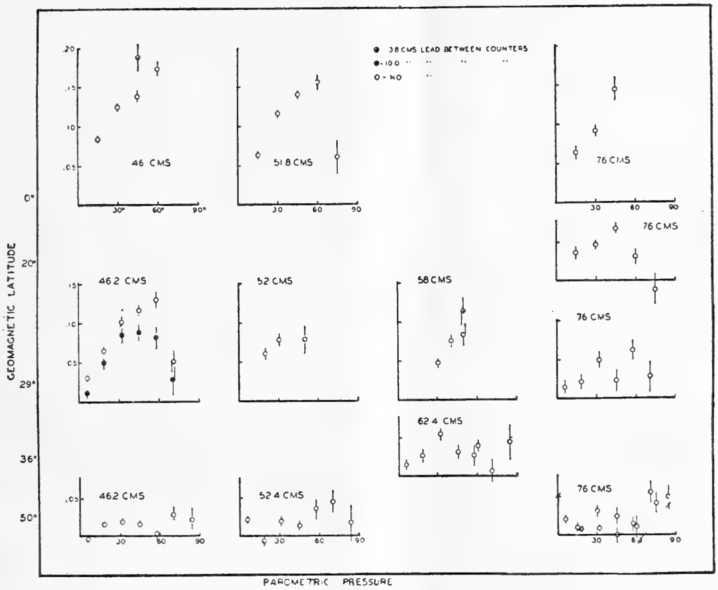

Fig. 3.—Combined results of the measurements of east-west asymmetries. Ratio of east-west intensity difference to average intensity plotted against zenith angle. Stations arranged in order of their latitudes and elevations. (From Johnson.)

The figures cited apply to the rays that enter from the vertical direction, but there is also a strong dependence of the low-energy limit upon the direction at any given latitude. In the case of positive primary rays, the lowest energies are found near the western horizon, and negative rays enter with lowest energy from the eastern horizon. At the Equator positive rays of 10 billion volts have access to the west, but 75 billion volts are necessary for entry from the eastern horizon. If more rays are positive than negative, this dependence of the low-energy limit upon direction should give rise to an east-west asymmetry of the intensity, since rays of lower energy can contribute to the intensity on one side of the meridian but not on the other. Experiments with instruments that measured the intensity from within a narrow cone of directions were made in the lower part of the atmosphere by the writer and by a number of other observers, and more intensity was found from the west than from the east at a corresponding angle from the vertical (Fig. 3). The results lent additional support to the hypothesis that the primary rays were electrically charged, and they showed that more of these rays were positive than negative.

Besides establishing the validity of the corpuscular hypothesis, the experiments with the directional and latitude effects were able to determine what the initial energies of the primary rays were before their entry into the atmosphere, and this was an important aid in analyzing the processes by which the rays lose energy in traversing the atmosphere. The differential intensity between two latitudes or between two directions could be identified with primary rays of given energy, and the intensity at any depth could be resolved into a kind of spectrum analysis with respect to the energy of the primary radiation. An analysis of this type based upon Compton and Turner's measurements on the Pacific Ocean is shown in Fig. 4.

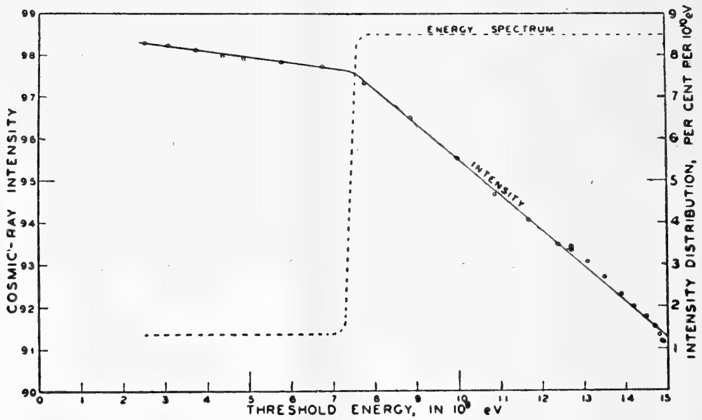

Fig. 4.—Spectrum analysis of the intensity of the cosmic radiation at sea level with respect to the energy of the primary rays. The full-lined curve represents the measured intensities plotted against the low-energy limit. This intensity is contributed by primary rays of energy greater than that value. The derivative of the full-lined curve is represented by the dotted curve and it is equal to the intensity contributed by primary rays within a unit range of energy about the value indicated by the abscissa. The sudden rise in the dotted curve at 6 billion volts may be explained if rays of greater than this energy penetrate the atmosphere while rays of less energy do not, or it may indicate a lower intensity of primary rays of low energy. (From Compton and Turner.)

From the total amount of the intensity difference between high and low latitudes we know that at least 15 percent of the sea-level intensity is produced by electrically charged primary rays whose energies lie between 6 and 18 billion volts. The earth's field is not strong enough to permit the analysis to extend to higher energies, and the remaining 85 percent of the sea-level intensity may be produced by electrically charged rays of higher energies or it may be produced by neutral rays.

The variation of the cosmic-ray intensity with latitude has also been studied by Bowen, Millikan, and Neher at levels up to within 1 or 2 percent of the top of the atmosphere. Instruments were sent up in free balloons, which were recovered after the flight and the records extracted. The dependence of the intensity upon latitude which they have found is shown in Fig. 5, where the ionization is plotted against depth in the atmosphere. From these curves the total energy brought in in each latitude can be determined by integration. This quantity divided by the average energy of a primary ray, determined from the latitude, gives the number of primary rays incident upon unit area per second at each latitude. The differences in these numbers from one latitude to another give the numbers of

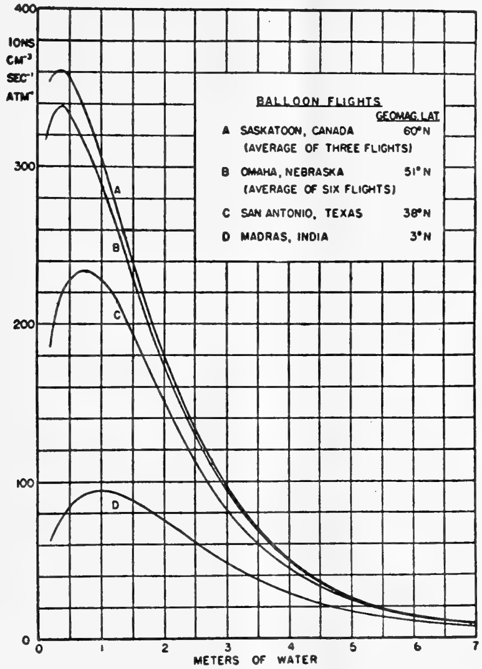

Fig. 5.—The intensity-depth curves of the cosmic radiation at different latitudes obtained from balloon flights. Atmospheric depths are represented in equivalent meters of water. The peak intensity at the Equator is about 40 per cent of that found in higher latitudes. The difference is due to the rays of lower energies cut off by the magnetic field. (From Bowen, Millikan, and Neher.)

primaries in short ranges of energy, or, in other words, the spectrum of the primary cosmic radiation. When smoothed out into a continuous curve this spectrum is represented in Fig. 6. This shows the energy distribution of the cosmic radiation as it would appear to an observer in interstellar space. Eighty-five percent of the rays have an energy less than 18 billion volts; the remaining 15 percent may be charged rays of higher energy or they may be electrically neutral.

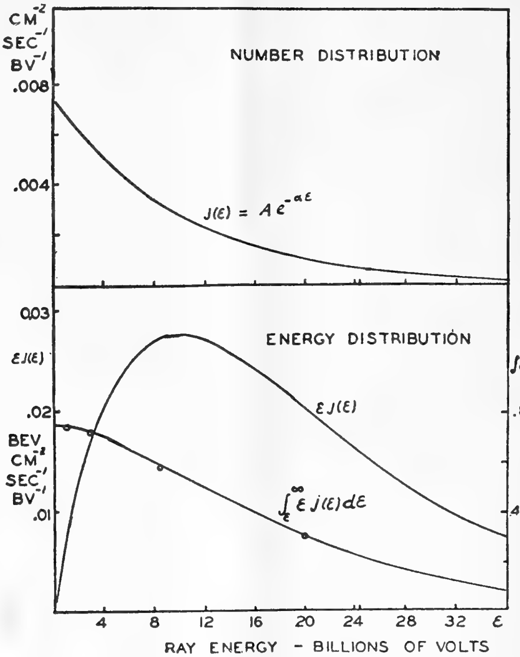

Fig. 6.—The spectrum analysis of the primary cosmic rays, based upon the balloon flight data of Bowen, Millikan, and Neher. In the upper diagram is plotted the curve showing the number of cosmic rays of different energies and in the lower diagram are the curves showing the distribution of the energy carried by primary cosmic rays and the energy carried by rays of energy greater than the value indicated by the abscissa. The latter curve has been plotted to fit the four points obtained from the experiments. (From Johnson.)

The above analysis pertains to the primary rays before they enter the atmosphere. A magnetic analysis based upon similar principles has also been made of the rays present in the atmosphere at sea level. In this instance the curvature of the tracks of ionizing rays in the Wilson cloud chamber has been studied when a strong magnetic field is applied to the chamber. The smaller dimensions of the chamber with respect to those of the earth are compensated by a stronger field and an ability to detect smaller deflections, so that the upper limit to which this analysis extends is actually a little greater than that of the geomagnetic analysis. The distribution of the ionizing rays found by Blackett is shown in Fig. 7, where the numbers of rays found at sea level within narrow ranges of energy are plotted against their energy. Here again the accurately measured energies extend up to about 20 billion volts, but in these experiments other rays of still higher energies, although undeflected in the strongest fields, may be recognized as electrically charged corpuscles from the fact that they produce tracks of ionization.

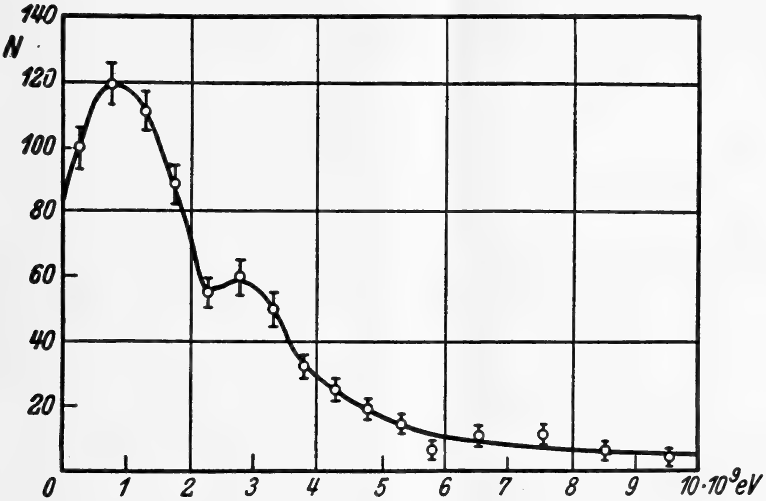

Fig. 7.—The energy distribution of the ionizing rays at sea level determined from measurements of curvatures of tracks in the cloud chamber with magnetic field. Accurately measured energies extend to 10 billion volts, rough measurements to 20 billion volts, but above this energy there are other corpuscular rays whose energies are so high that no curvature can be seen. The loop in the curve at 2.5 billion volts has not been explained. (From Blackett.)

Beyond the range of the magnetic measurements other techniques indicate still higher energies of cosmic rays. From studies of the energy lost by rays in passing through unit thickness of matter it has been found that a ray loses about 3 million volts per centimeter of water. V. Wilson and others have detected cosmic rays to a depth of 1,200 meters of water, from which it may be concluded that some of the cosmic rays have energies in excess of 10^{11} volts. Still higher energies are indicated by the study of the bursts of ionization that occasionally take place in an ionization vessel (Fig. 8). This phenomenon, discovered by Hoffmann, is now a matter of every-day observation on the part of those who measure cosmic-ray ionization. The sudden release of ions within the vessel sometimes observed indicates that thousands of ionizing rays must have passed through the chamber at one time. If these rays have the same average energy as the other cosmic rays, the total energy carried by them must exceed 10^{12} volts. Since they occur simultaneously they must all have come from a single primary ray. These bursts have also been observed in the cloud chamber, and examples photographed by Fussell and Street are shown in Figs. 9 and 10. In Fig. 10 more than 100 rays are seen entering the chamber from nearly parallel directions, indicating that this is only a small sample of the burst that must have originated from some point well above the chamber. Some recent experiments by Janossy and Lovell, by Auger, and by Swann and Ramsey have shown that bursts sometimes cover an area as great as 400 square meters and have energies up to 10^{15} volts.

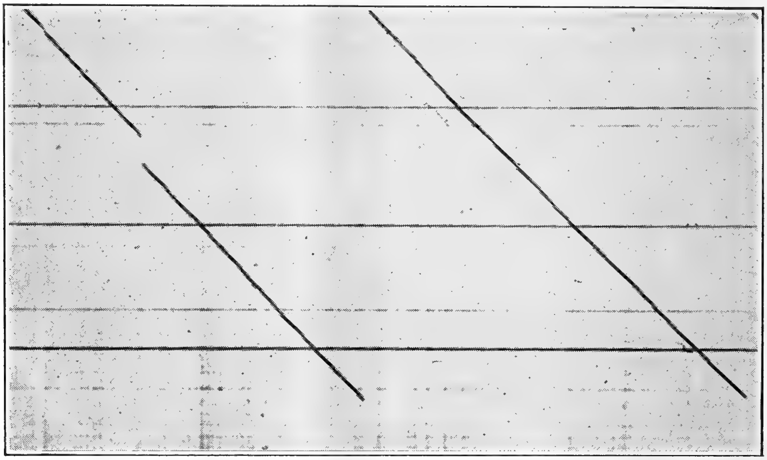

Fig. 8.—An ionization burst recorded automatically in a vessel designed by Millikan and Neher. The sloping lines indicate the drift of the needle of the electroscope as the cosmic-ray ionization accumulates for a period of 15 minutes. The sudden break in one of the records was produced by the sudden release of ions attributed to the simultaneous passage of at least 100 rays. (From Korff.)

These experiments show that at least a good part of the primary radiation previously characterized as unanalyzable, in the sense that it was impossible to tell from the geomagnetic effects whether it consisted of neutral rays or of electrically charged rays, must now be attributed to the latter. We can not avoid postulating the existence of the enormous energies required to reach the earth at the Equator by supposing the equatorial intensity is produced by neutral rays.

The primary rays are electrically charged; but what kind of corpuscles are they? Are they protons, electrons, or alpha particles, or are they some new kind of charged particle not represented in the familiar family of elementary particles? To answer this question we may look to the interaction of the rays with matter for more evidence. Even in the earlier attempts to analyze the ionization-depth curve, as we have already indicated, there appeared to be several groups of cosmic rays of different penetrating power. Although these analyses were based upon the wrong hypothesis as to the nature of the primary radiation, the resolution of the observed curve into an absorption-coefficient spectrum (Fig. 11) shows two groups of rays so well defined that their apparent differences could not be attributed to the wrong method of analysis. The distinction between the two groups, at first attributed to a difference in energy, must now, in view of the studies of the latitude effect, be interpreted as a difference in some other property. Some of the soft rays so easily absorbed by the atmosphere that none at all reach to a depth greater than 0.6 atmosphere are now known to be present at the Equator and to have energies

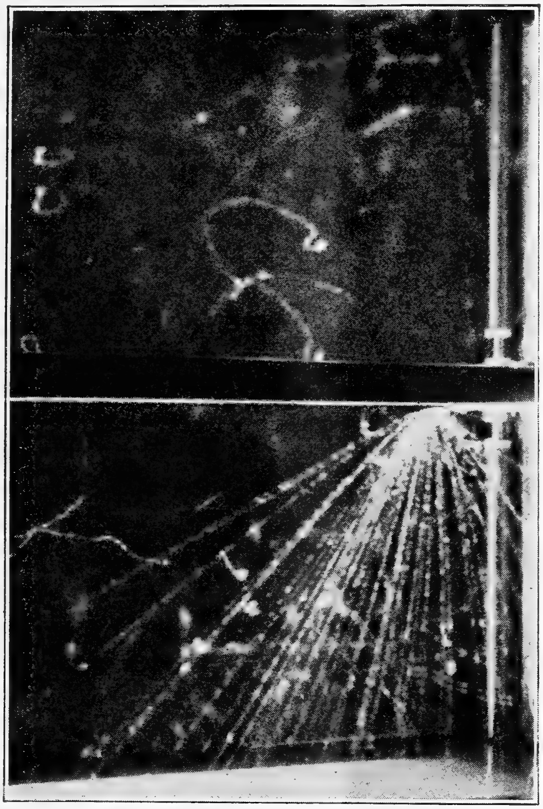

Fig. 9.—A Wilson cloud-chamber photograph of a burst of rays emanating from a point in a piece of lead. Events such as these also account for the bursts of ionization. (From Fussell and Street.)

exceeding 18 billion volts. On the other hand, some of the hard rays capable of passing through the whole atmosphere are excluded from latitudes below 40° and are known to have energies less than 6 billion volts. Within this range of energies we find both hard and soft rays, and it is necessary to seek for some other difference than the energy in distinguishing the hard rays from the soft.

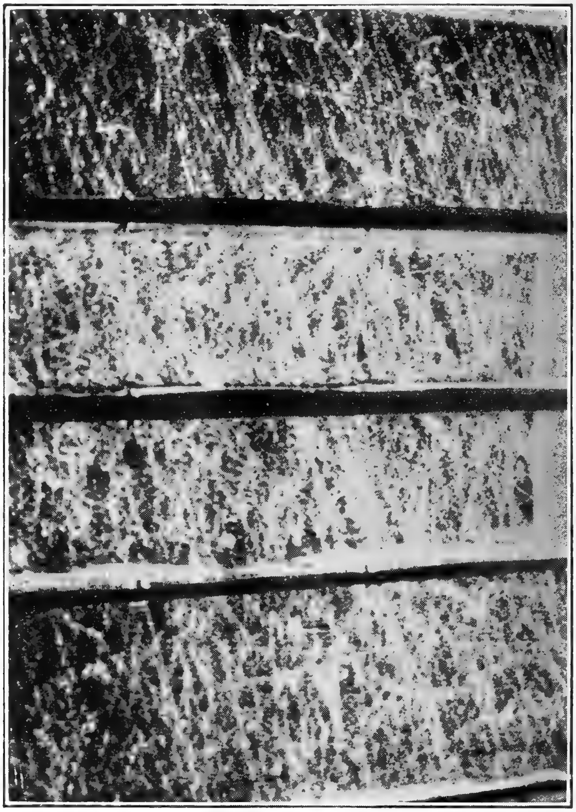

Fig. 10.—A large burst of nearly parallel rays entering the chamber from above and undergoing multiplication in the lead plates placed in the chamber. The rays here seen entering the chamber must have branched off from the primary particle at a considerable distance above the apparatus and what is seen is probably but a small sample of the whole burst. These bursts sometimes cover an area of 400 square meters and contain rays whose energies total 10^{15} volts. Because of their simultaneity the energy must have originated from a single primary ray. (From Fussell and Street.)

Perhaps physicists would not have given up hope of explaining the absorption of the cosmic rays in the atmosphere without having to introduce the complexity of two different kinds of rays were it not for other more direct evidence requiring the same hypothesis. In the first place there were large differences in the energies lost by rays as they passed through lead sheets. This effect was studied in the cloud chamber by Anderson and Neddermeyer and by Blackett. The energies of the ray before and after its transit through the lead were determined from the curvature of the track (Fig. 12), and the energy lost was plotted against the average energy (Fig. 13). In spite of the rather large fluctuations the rays seem to fall definitely into two groups, those for which the loss of energy is proportional to the energy, and the point falls along the 45° line in the figure, and those suffering slight energy losses independent of the energy of the ray for which the points fall along the axis. Even this evidence might have been attributed to fluctuations in the behavior of the rays were it not for the additional characteristic noted by Anderson and Neddermeyer that the strongly absorbed rays represented by points on the 45° line were usually accompanied by other rays either emanating from the lead plate or entering the chamber from above, whereas the rays that lost little energy in the lead were rarely accompanied by other rays. Simultaneously with this discovery, Street and Stevenson found that rays able to penetrate great thicknesses of lead, up to 1 meter, seldom produced showers of secondary rays, whereas those that were easily stopped in lead produced frequent showers. Simultaneous measurements of the energy in the cloud chamber showed that the difference in behavior was not associated with a difference

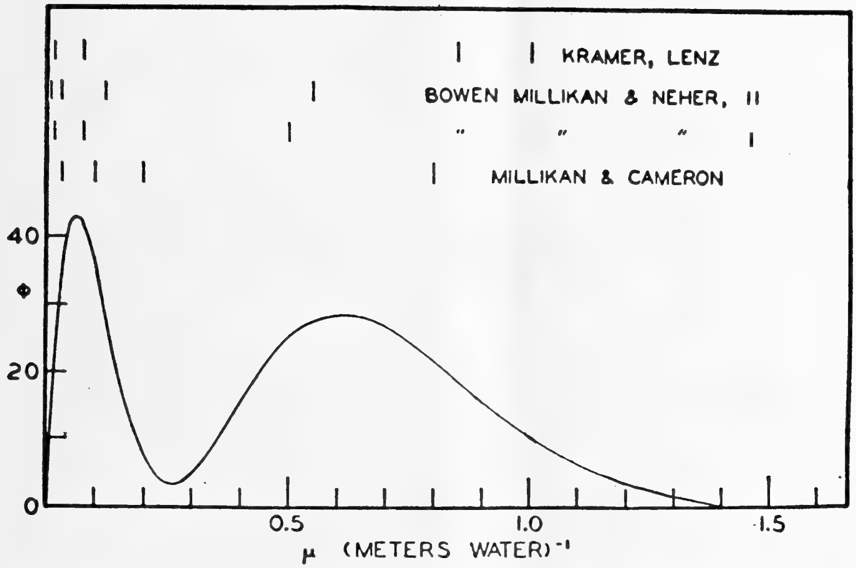

Fig. 11.—An analysis of the ionization-depth curve into a spectrum of absorption coefficients based upon the assumption of exponential absorption. Although this law is now known to be invalid, the existence of the two well-pronounced peaks would not be altered in taking cognizance of the true absorption law. (From Eckhart.)

in energy. These and other experiments, not to be mentioned, definitely showed that two kinds of cosmic rays appear at sea level, the hard rays making up about 70 percent of the total and the soft rays accounting for the remainder. At higher elevations the soft rays become more prominent and account for most of the intensity in the stratosphere.

If one is to be able to identify different kinds of rays by their differences in behavior it is necessary to know how different kinds of rays behave. Unfortunately the necessary information can not be obtained by direct observation, for there is no laboratory technique for producing rays of known types with the energies of the cosmic rays. The only approach to the problem is through the theory. In this instance, however, the theory seemed to be particularly reliable in spite of its not having been put to rigorous test, and it was able, in the hands of Bethe and Heitler, to make some specific predictions. Two kinds of energy losses were described, the ionization losses associated with the interaction between the ray and the electrons in the atoms of the absorbing matter, and the radiation losses arising from the nuclear encounters. For rays of given energy these two types of energy loss depend so differently upon the mass of the particle that this might be the key to the difference in the observed behaviors of the two types of rays. The ionization losses are inversely propor-

Fig. 12.—Photograph of a ray losing energy in a lead plate. A greater curvature of the track in the lower half of the photograph is noted corresponding to a lower energy after it has emerged from the lead. (From Anderson.)

tional to the velocity, so that when two rays of different mass have the same energy the heavier one will ionize the more heavily. When the velocity approaches that of light the ionization ceases to vary with the energy and has a low density. The energy at which the ion density reaches this low value depends upon the mass and is about equal to the mass energy *mc.*[2] The radiation losses, on the other hand, increase with the energy in proportion to it, but the absolute value of the losses experienced by this process depend upon the inverse square of the mass. Thus a proton loses energy by this process only one four-millionth as rapidly as an electron of the same energy. In the case of the electron the theory showed that the radiation losses should equal the ionization losses at an energy of 1.5 million volts, and for higher energies it should predominate. Protons, on the other hand, lose energy principally by ionization until their energy exceeds 10^{12} volts.

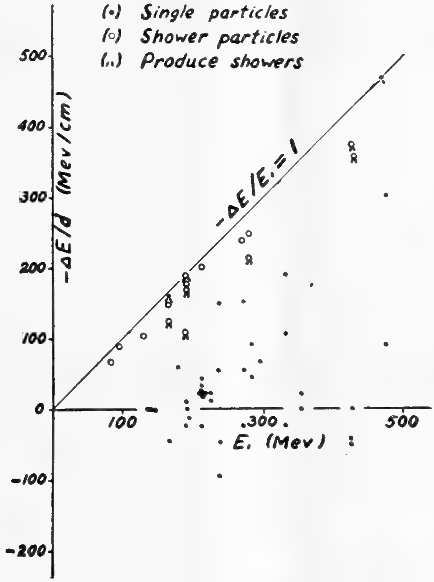

Fig. 13.—The loss of energy per unit thickness of lead plotted against the average energy. Rays that are accompanied by other rays are indicated by the open circles. Rays that produce showers of rays in the lead plate are indicated by tails and single rays are indicated by the black dots. The points appear to fall into two groups, those that lose little energy and fall along the axis and those that lose energy in proportion to their energy and fall along the 45° line. The latter group are also distinguished by their shower-producing tendency and their frequent occurrence along with other rays. (From Anderson and Neddermeyer.)

The quantum theory foretold another phenomenon that proved of great importance in the identification of the rays, for it predicted that the radiation lost by the particles during nuclear encounters would soon appear again in the form of a pair of positive and negative electrons created as the quantum passes through a nuclear field. Thus rays that lose energy by radiation could be identified by their family of secondaries.

In comparing the theory with the experimental results it was found that the observed energy losses of the soft component in the cloud-chamber experiments (Fig. 13) were just those to be expected if the rays concerned were electrons. The secondary rays observed by Anderson and Neddermeyer accompanying the rays whose energy losses were large were also in the right proportion to be accounted for by the pair-formation process described by the theory. The theory based upon the primary electron hypothesis was equally successful when applied to the variation of the intensity in the upper atmosphere by Carlson and Oppenheimer and by Bethe and Heitler. If the primary rays were electrons of the energies determined by the latitude effect the multiplication provided by the radiative and pair-formation processes gave just the observed increase of intensity over the first part of the curve (Fig. 14), and it explained the first part of the downward slope.

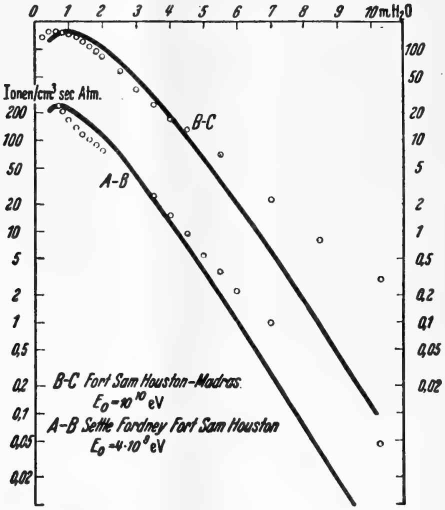

Fig. 14.—Logarithmic plot of the increments of intensity in the atmosphere between two latitudes attributable to rays of definite energies (represented by the points) and the curves showing the theoretical variation of the intensity to be expected from the multiplicative processes if the primary rays are electrons of these energies. (From Euler.)

A third important success of the theory pointed out by Montgomery and Euler was its ability to account for the observed frequency and size distribution of the bursts and showers of rays observed in the ionization chamber. This was accomplished without the introduction of any *ad hoc* hypotheses but merely from consideration of the fluctuations if the elementary processes of radiation and pair formation were independently occurring events, taking place with the *a priori* probabilities indicated by the theory.

In every respect, in the cloud chamber, in the atmosphere, and in the ionization chamber, rays of the soft component were behaving as electrons obeying the theory should behave. Even though the theory was not previously proved in this range of energies and even though it was not known that the soft rays were electrons, the combination of circumstances gave potent support to both hypotheses.

The hard rays on the other hand were not behaving as electrons, for they experienced no large losses of energy like the radiative losses of the soft component, and there were no positive and negative pairs of electrons being produced by them. If these rays were to be described by the theory it would be necessary to ascribe to them a mass somewhat larger than that of the electron.

The first guess was naturally that the hard rays were protons. To be sure, they occurred with both signs of charge in about equal numbers, but this aspect of the situation was not objectionable for physicists with their love for symmetry had been looking for negative protons. However, this hypothesis was of short duration, for tracks of hard rays were found in the cloud chamber with a low density of ionization indicating an energy greater than the mass energy, but simultaneous measurements of their curvature in a magnetic field showed that this energy was less than the mass energy of the proton. If the theory applied these rays would have to have a mass in between that of the electron and of the proton. No particle of this type was previously known and it became necessary to admit into the family of elementary particles a new member christened the *mesotron*, from the Greek stems indicating a ray of intermediate mass.

Further more careful studies of some of the slower mesotron tracks showed that they began to thicken when their energy fell below 10^8 volts, and it was concluded that the mass was about one-tenth that of the proton. A mesotron track photographed by Williams and Pickup is shown in Fig. 15, where it may be compared with the thinner but more sharply curved track of a faster but less energetic electron. An equally curved track of a proton would have been 100 times more dense and a proton track of equal density would have shown no detectable curvature. Thus there can be no mistake in distinguishing these rays from either protons or electrons, although a high accuracy has never been claimed in the actual determination of the mass.

As already noted, the first part of the ionization-depth curve is satisfactorily accounted for by primary electrons. It would be hoped that the variations of intensity at the greater depths where the hard component predominates might be accounted for in terms of the properties of the mesotron. Indeed, if one takes the energy distribution found from the cloud-chamber analysis at sea level and calculates what mesotron intensities there should be at various depths below sea level, the result is in satisfactory agreement with the experiments, but if one works backward and calculates what energy the primary rays must have had before their entry into the atmosphere, the calculation shows energies less than could have been admitted through the magnetic field. The energy losses contemplated by the theory can not account for the difference between the observed sea-level energies and those that the primary rays must have had. Since the theory is complete in its description of what happens below sea level we must admit that the mesotrons are not primary rays but that they have been produced near the top of the atmosphere by some other more energetic primary radiation.

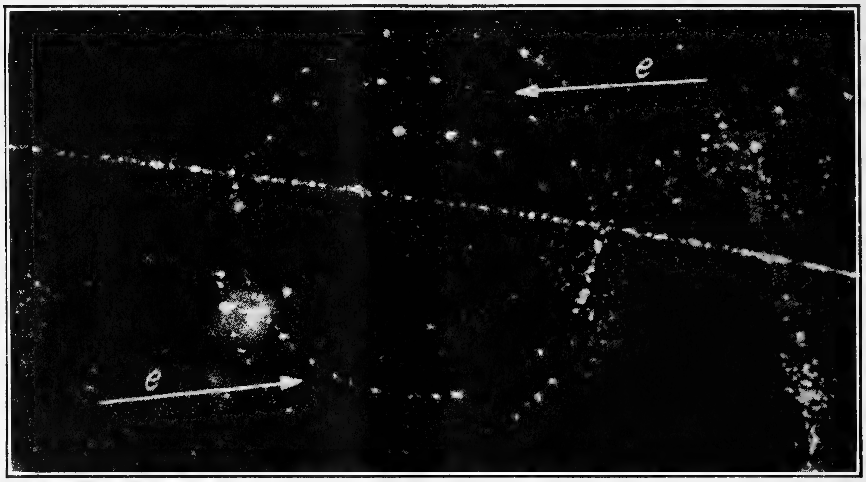

Fig. 15.—A mesotron track photographed by Williams and Pickup (the straighter track) compared with the track of an electron. The thinner electron track means that the ray was moving with a higher velocity, but its greater curvature indicates a lower momentum. The two conditions are consistent if the mesotron has a larger mass.

There are two other important arguments leading to this same conclusion. In the first place, the east-west asymmetry of the hard rays at sea level near the Equator shows that the primary rays are predominantly positive. The cloud chamber analysis, on the contrary, shows equal numbers of positive and negative mesotrons at sea level. The second argument is based upon the evidence that a mesotron is unstable and could not have survived a long time in interstellar space without having disintegrated into an electron and a neutrino. Perhaps a digression from the main thesis would be allowed for a brief description of this evidence.

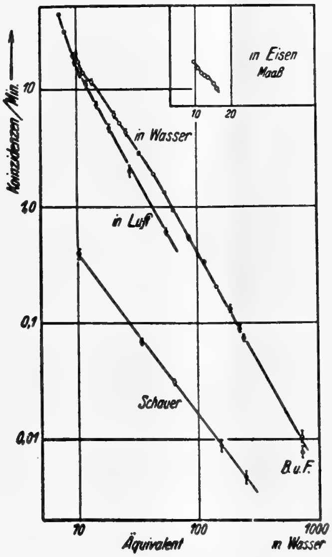

Fig. 16.—The intensity of cosmic rays under water and under equal masses of air. The greater intensity is found under the more dense medium where the time of transit is least. The effect is explained if the mesotrons are unstable and have a mean life of the order of 2×10^{-6} seconds. (From Ehmert.)

The first hint of an instability of the mesotron component appeared in a theory of Yukawa in which a particle of mass like that of the mesotron found in the cosmic radiation was invoked for an interpretation of nuclear forces. The connection was vague, and it is doubtful if any significance would have been attached to the instability predicted by Yukawa for his nuclear particle were it not for the fact that the same property was needed to account for certain unexplained effects in the cosmic radiation. Ehmert had measured the intensity of the cosmic radiation under air and under equal masses of water (Fig. 16) and had found that although these substances differ only in regard to their density, the one-thousand-fold denser water was the more transparent to the cosmic radiation. A similar effect was found by Ehrenfest and Freon when they compared the intensities of rays that had traversed equal masses of air at different pressures (Fig. 17). Both experiments could be explained by the instability hypothesis, for the greater intensity was always found along the path requiring the least time for transit from the upper atmosphere. Mr. Pomerantz and the writer have recently repeated these experiments under more favorable circumstances by comparing the intensities under an equivalent of two atmospheres of air made up in the first instance of the vertical path through the atmosphere and the equivalent of one atmosphere of water in a cylindrical tank above the instrument, and in the other instance by the air path along the inclined direction 60° from the vertical. These measurements indicate a mean life of the mesotron when at rest of 2.5×10^{-6} seconds. Because of a relativity transformation of the time scale when passing from the reference frame of the mesotron to that of the observer the mean life increases with the energy, and this is a phenomenon that has also been confirmed in these experiments. The products of disintegration are electrons and neutrinos. Euler has shown that the energy distribution and the intensity of the soft component at sea level is just that

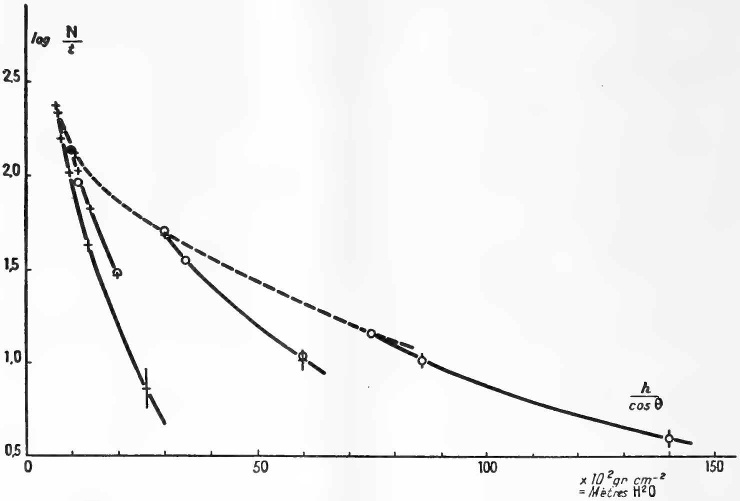

Fig. 17.—Curves showing the cosmic-ray intensity as a function of the mass of absorbing matter traversed. The dotted curve is that obtained from measurements in the atmosphere in the vertical direction. In the other curves the instrument was inclined with respect to the vertical and the measurements carried out at four elevations. (From Ehrenfest and Freon.)

to be expected if it consists of the disintegration electrons from the hard component. Thus there is experimental evidence from many angles that the mesotrons are unstable, and although this presents some interesting problems of its own its bearing upon the main thesis is that it requires the mesotrons in the atmosphere to be secondaries of some other type of stable primary radiation.

Perhaps the simplest assumption is that the primaries of the mesotrons are the electrons, which as we have already seen, account satisfactorily for the soft component. If these produce mesotrons by impact with the nuclei in the upper atmosphere they might also account for the hard component. This has been a tempting idea and one which has formed the basis of several theoretical discussions of the probability of mesotron production, but it now appears to be no longer tenable, because of some very recent results.

It has already been noted that the east-west asymmetry of the cosmic radiation at sea level shows that the primaries of the mesotron component are positive. If these primaries are the electrons of the soft component all other secondaries produced by them should also show the same east-west asymmetry, and at the top of the atmosphere where the intensity is produced in such large measure by the field-sensitive rays, as shown by the latitude effect, the asymmetry should be at least 10 times greater than that found at sea level. Dr. Barry and the writer have just completed experiments to test this prediction by measuring the relative intensities of the radiation from the east and the west near the Equator at very high elevations. Unidirectional recording instruments set at an angle just above the horizon were sent up in free balloons to within a few percent of the top of the atmosphere and there allowed to rotate about a vertical axis. The orientation as well as the cosmic-ray intensity and barometric heights was communicated to the ground station by radio signals automatically sent out from the balloon. Five flights of this nature gave results that agreed with one another in showing that the asymmetry was no more than could be accounted for by the hard component alone and that the soft component primaries must consist of equal numbers of positives and negatives. If the soft component primaries had been as predominantly positive as those of the hard component the asymmetry would have been at least 8 times more pronounced than that observed. Since the soft component primaries are equally positive and negative, while the hard component primaries are entirely positive, the two components must be produced by different primary rays, the soft component primaries consisting of equal numbers of positive and negative electrons, and the primary rays of the hard component consisting of practically 100 percent positive rays whose only other known property is their stability to withstand long times of transit through interstellar space.

These rays are not electrons and they are not mesotrons. Perhaps then they are protons. Arguments against this hypothesis have been advanced. Protons losing energy by ionization alone should reach sea level in large numbers, and they should be identifiable from the character of their track and their curvature in the cloud chamber after they have been slowed down to an energy comparable with their mass energy of 10^9 volts, but numerous attempts have failed to find any trace of primary protons. The theory, also, though still very vague, fails to find any very good reason why protons should produce mesotrons. On the other hand, if protons produce mesotrons perhaps the same interaction could explain why protons do not reach sea level and the hypothesis might still be allowed.

Another approach to the problem is through a consideration of the properties of interstellar space from which the particles arrive. Swann has pointed out what enormous potential differences would exist between points in space if all or any appreciable fraction of the primary radiation were made up entirely of charges of one sign. If, for example, one-tenth of the primary radiation consisted of positives unneutralized by an equal number of negatives, potentials of 10^{17} volts would exist between two points separated by a distance of 1 light year, and the potentials go up as the square of the distance. The fact that cosmic rays come to us at all is the best possible evidence that there is no space charge in interstellar regions. Any element of volume must have equal numbers of positive and negative rays within it. It is also easy to see that the positives and the negatives must be moving with statistically equal velocities, for otherwise there would be more charges of one sign than of the other passing out through a closed surface surrounding the source and the source would go on charging up to an infinite potential and shut off the primary beam. The only way to realize a steady potential at the source and at the same time to have a neutral intergalactic space is to have equal numbers of positives and negatives in each element of volume both moving with the same velocities.

But how then can one find more positive than negative cosmic rays in any given range of energy as the rays impinge upon the earth? The answer must be that positive and negative rays of equal *velocity* do not possess equal *energies.* They must have different masses. Since the energies of two rays of equal velocities are in proportion to their rest masses, a proton moving with the same velocity as an electron would have 2,000 times more energy. When these encountered the earth's magnetic field, the more energetic proton would pass on through while the electron would be turned back into space, and the primary rays would appear to be entirely positive. From this point of view, therefore, we can account for the preponderance of positive rays in the primary beam by merely assuming that the positives have the greater mass.

If we consider the source of the cosmic radiation in a little closer detail we can see that this picture of the primary radiation is also consistent with what we might expect if the source is composed of ordinary matter. If some mechanism, such as the thunderstorm, were producing high-energy rays of either sign, these would be propelled outward leaving the opposite charge on the source. In this field ions of sign opposite to that of the initial rays would be accelerated outward, while the initial rays would be decelerated. Finally, at a sufficiently great distance the two would have the same velocity and the positives with the greater mass would have most of the original energy.

If the initial rays were electrons, the soft component primaries could also be accounted for in the same picture, for the initial electrons before their deceleration would have produced positive and negative pairs as they were passing outward through the atmosphere of the source. If this multiplication takes place according to our present knowledge of pair formation, these would have the energy distribution which is observed, and they would consist of equal numbers of positives and negatives moving with statistically equal velocities, just as is observed.

In this way we can account for all the observed rays in the primary beam, but it is also necessary to account for the absence of gamma rays. If the soft component is produced by pair formation at the source, there should also be a nearly equal number of gamma rays in the primary beam, which should show itself as a component not sensitive to the magnetic field of the earth, and yet the latitude effect shows that at least 85 percent of the primary rays are electrically charged. One possible solution of this difficulty has been suggested by Alfven who considers the possibility of the existence of a galactic magnetic field. If the source of the radiation is within the galaxy the electrically charged rays would spiral around in planetary orbits within a region from which they could never depart while the gamma rays would pass freely out and be lost in intergalactic space. This idea of a galactic source trapped by a magnetic field is also supported by the experiments of Compton and Getting, which have shown that the diurnal variation is less than is consistent with an extragalactic source when the proper motion of the solar system due to the rotation of the galaxy is taken into account.

Where the source is, we may not yet say, but some recent evidence found by Forbush in the very important program of the Carnegie Institution for the study of the time variations of the intensity show the presence of some unexplained variations of the intensity associated with magnetic storms and other long-time variations that may have the period of the sun-spot cycle. If these effects are produced by solar influence—as they seem to be—a source of cosmic rays may be considerably closer to us that we have heretofore imagined.

BOTANY.—*Concerning* Ardisia crispa *(Thunb.) A. DC. and* A. crenata *Sims, confused species of Myrsinaceae from eastern Asia.*[1]

EGBERT H. WALKER, U. S. National Museum.

The name *Ardisia crispa* is usually applied to a woody plant of eastern Asia commonly cultivated in greenhouses in Europe and the United States, although this species is sometimes called *Ardisia crenata*. In Japan, where it is also cultivated, it is known under various names.[2] It was originally described as *Bladhia crispa* by the Swedish botanist Thunberg[3] in 1784. In 1817 the English horticulturist Loddiges published an illustration of a shrub recently introduced from China, which he named *Ardisia crenulata* but did not describe. The following year this plant was described and renamed *Ardisia crenata* by the English botanist Sims. In 1834 Alphonse DeCandolle in his review of this family (Trans. Linn. Soc. London **17**: 95–138. *pl. 4–8*) transferred *Bladhia crispa* Thunb. to *Ardisia*, but his description and the fact that he cited *A. crenata* Sims as a synonym show that he misunderstood Thunberg's species and misapplied his name to the plants illustrated by Loddiges and by Sims. This mistake has resulted in long-continued confusion, which was only recently clearly resolved by Dr. H. Handel-Mazzetti in his Symbolae Sinicae (Teil **7**: 755–756. 1936). He examined Thunberg's

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[1] Published by permission of the Secretary of the Smithsonian Institution. Received March 13, 1939.

[2] See formal synonymy below.

[3] For precise references see the formal synonymy.

type specimen, preserved in the herbarium at Upsala, and found that it is not the same as that of Sims but is the same as *A. hortorum* Maxim. published in 1865 and *A. Henryi* Hemsl. published in 1886. Because of the misapplication of this name by DeCandolle and its perpetuation in literature, Dr. Handel-Mazzetti rejects Thunberg's name, calling it a "nomen confusum," and takes up the next oldest name *A. hortorum* Maxim. as the valid one for *Bladhia crispa* Thunb. However, since DeCandolle based his name *Ardisia crispa* on Thunberg's species, the types are the same regardless of his misapplication. Therefore *Bladhia crispa* Thunb., transferred to *Ardisia* as *A. crispa* (Thunb.) A. DC., must be applied in its original sense. This interpretation is also presented by Dr. A. Rehder in his treatment of the woody plants described by H. Léveillé (Journ. Arnold Arb. **18:** 232. 1937).

Ardisia hortorum was described by the Russian botanist Maximowicz from live material from Japanese gardens. He contrasts it with other living specimens growing in the St. Petersburg botanical garden under the name *Ardisia crispa* A. DC. (*A. lentiginosa* Ker) and with *A. punctata* Lindl.

Ardisia Henryi Hemsl. was described from specimens collected in Hupeh Province, China, by Augustine Henry, nos. 3455 and 3972, and by E. Faber from Szechwan, all of which have been examined by Dr. Handel-Mazzetti. The writer has examined duplicates of the Henry specimens at the United States National Herbarium, the Gray Herbarium, and the Arnold Arboretum and a specimen at the New York Botanical Garden designated as *Faber* 172 from Szechwan, which conforms with the Henry specimens and which probably is a duplicate of the collection cited by Hemsley. Handel-Mazzetti's placing of this species with *Bladhia crispa* Thunb. through comparison of types,[4] and with *Ardisia hortorum* Maxim., is confirmed by the writer's studies of many specimens and much literature. In respect to published descriptions there is considerable diversity in characters used. Too great reliance seems to have been placed on punctation and other variable leaf factors. The characters used in this paper to differentiate these species have been selected after 10 years' study of the eastern Asiatic species of this family. The characters used by Dr. Carl Mez in his monograph of this family (Pflanzenreich **9** (IV. 236) 1902) have proved unreliable. Furthermore, his inclusion of these two distinct species along with one other under the name *Ardisia*

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[4] He has very kindly sent the writer a carefully prepared drawing of a leaf by which Thunberg's and Hemsley's species have been further confirmed as identical.

crispa (Thunb.) A. DC. has continued the confusion started by DeCandolle's error.

The specimens upon which the present paper is based will be cited in the writer's revision of the eastern Asiatic Myrsinaceae.

KEY

1. Stems minutely puberulent or lepidote when young; leaves membranous, rarely punctate beneath, the margin entire or wavy, not crisped-undulate; sepals not at all or sparsely punctate; stems usually conspicuously elongating above the special flowering branches . . . . *A. crispa*
2. Stems glabrous when young; leaves chartaceous or coriaceous, usually raised-punctate beneath, the margin usually crisped-undulate; sepals scattered-punctate; stems usually not conspicuously elongating above the special flowering branches . . . . *A. crenata*

ARDISIA CRISPA (Thunb.) A. DC. Fig. 1

Bladhia crispa Thunb. Fl. Japon. 97. 1784. "Crescit in insula Nipon." The type, in the herbarium of the University of Upsala, has been examined by Handel-Mazzetti (Symbolae Sinicae, Teil **7**: 756. 1936).

Ardisia crispa (Thunb.) A. DC. Trans. Linn. Soc. **17**: 124. 1834; DC. Prodr. **8**: 134. 1844. Based on *Bladhia crispa* Thunb. but misapplied by DeCandolle.

Ardisia hortorum Maxim. Gartenflora **14**: 363. *pl. 491.* 1865. Based on cultivated plants at the St. Petersburg botanical garden, received from cultivation in Japan.

Ardisia Henryi Hemsl. Journ. Linn. Soc. Bot. **26**: 65. 1889. Based on Kew specimens of *Henry* 3455, 3972 from Hupeh (duplicates seen at the U. S. National Herbarium, the Gray Herbarium, and the Arnold Arboretum), and *Faber* (without number) from Mount Omei, Szechwan (probable duplicate seen at the New York Botanical Garden, there designated as *Faber* 172).

A shrub or undershrub up to 1.5 m high, the erect stem unbranched except for the special flowering branches, usually minutely puberulent or lepidote; leaves membranous, elliptic-lanceolate or narrowly oblong-lanceolate, acute to long and slenderly acuminate, 6 to 15 cm long, 1.5 to 4 cm wide, entire or wavy with marginal glands, usually finely lepidote and raised-punctate beneath, the lateral nerves about 8 pairs, the marginal nerve very obscure or wanting; inflorescences usually simple, sometimes compound, subumbellate, terminal on special slender lateral branches 5 to 10 cm long, these usually with a few normal or reduced leaves near apex, glabrous, lepidote or minutely puberulent, usually several in axils of the lower leaves or below them; flowers white, 4 to 5 mm long, the sepals 1.5 mm long, oblong-ovate or lanceolate, acute or narrowly rounded, not at all or sparsely punctate, the anthers not punctate on back; fruit 5 to 6 mm in diameter, somewhat punctate.

Japan to Szechwan.

Ardisia crispa var. **amplifolia** Walker, var. nov. Fig. 2

Frutex 1–2 m altus, ramulis crassiusculis asperis; folia circa 25 cm longa, 5 cm lata, elliptico-lanceolata vel lanceolata, subtus obscure punctata, glandulis marginalibus donata, nervis lateralibus 13–20-jugis subtilibus in nervum marginalem non confluentibus; inflorescentiae simplices subumbellatae, in ramulis specialibus brevibus in anthesi fortasse foliaceis terminales;

Fig. 1.—(1) *Ardisia crispa* (Thunb.) A. DC: *a*, Whole plant with inflorescences, $\times\frac{1}{3}$, drawn from *Henry* no. 3455, at the Arnold Arboretum; *b*, corolla and stamens, $\times 3\frac{1}{3}$; *c*, stamen, back view, $\times 3\frac{1}{3}$; *d*, flower with corolla removed, $\times 3\frac{1}{3}$. Details drawn from *Henry* no. 6365, in the U. S. National Herbarium.

(2) *Ardisia crispa* var. *Dielsii* (Léveillé) Walker: Stem with inflorescences, $\times\frac{1}{3}$. Drawn from *Henry* no. 13279, in the U. S. National Herbarium.

sepala 2 mm vel minus longa, glabra, non punctata; fructus 5–6 mm longus, rubescens, non punctatus.

Type in the United States National Herbarium, no. 457204, collected by A. Henry in the mountains south of Mengtze, Yunnan, no. 9653; duplicates at the New York Botanical Garden and the Arnold Arboretum. Additional specimens seen are *Henry* 9653A and 9653B, both from the same locality and deposited in the New York Botanical Garden.

This variety differs from the typical form of the species in having thicker, rough stems, and larger and broader leaves with about twice as many lateral nerves.

Ardisia crispa var. **Dielsii** (Léveillé) Walker, comb. nov. Fig. 1 (2)

Ardisia Dielsii Léveillé, Repert. Sp. Nov. Fedde **9:** 461. 1911. Based on Bodinier (L. Martin) 1636 (erroneously cited as L. Martin 1636), collected June 1, 1898, in rocky woods on the college hill at Kouy-Yang, Kweichow, deposited in the Léveillé herbarium, now at the Royal Botanic Garden, Edinburgh. The type has been examined by the writer.

Fig. 2.—*Ardisia crispa* var. *amplifolia* Walker, var. nov.: *a*, Branchlet with fruiting inflorescences, ×⅓; *b*, fruit, ×3⅓. Drawn from a duplicate at the Arnold Arboretum of the type, *Henry* no. 9653.

Ardisia Henryi var. *Dielsii* Walker, Journ. Arnold Arb. **15:** 290. 1934. Based on *A. Dielsii* Léveillé. Handel-Mazzetti does not recognize this variety.

Ardisia hortorum var. *brachysepala* Hand.-Mazz. Symb. Sin. Teil **7:** 756. 1936. Based on *Handel-Mazzetti* 10716 from Kweichow; bamboo thicket on a hill at Dodjie between Badschae and Duyün; limestone of the subtropical zone, at altitude 700 m, July 13, 1917. The type has been examined by the writer.

This variety differs from the typical form of the species in having longer and more slender leaves, these narrowly long-lanceolate, 12 to 20 cm long, 1 to 4 cm wide, the lateral nerves very clearly curved-ascending.

Kwangsi, Kweichow, Szechwan, and Yunnan.

Ardisia crenata Sims

Ardisia crenulata Lodd. Bot. Cab. **1:** *pl. 2.* 1817. *Nomen nudum,* based on cultivated specimens from China.

Ardisia crenata Sims, Curtis's Bot. Mag. **45:** *pl. 1950.* 1818. Proposed as a new name for *A. crenulata* and accompanied by a description.

Ardisia lentiginosa J. B. Ker, Bot. Reg. **7:** *pl. 533.* 1821. Proposed as a change of the name *A. crenata* Sims, because of *A. crenata* Roxb. Hort. Beng. 85. 1814. That name, however, was a *nomen nudum* until the publication of a description in Roxb. Fl. Ind. ed. Carey **2:** 276. 1824. This name appears frequently in Japanese literature.

Ardisia crispa (Thunb.) A. DC., as misapplied in Trans. Linn. Soc. London **17:** 124. 1834; DC. Prodr. **8:** 134. 1844. DeCandolle transferred *Bladhia crispa* Thunb. but described *A. crenata* Sims, which he placed as a synonym.

An erect shrub or undershrub up to 1.5 m high, the glabrous stem usually unbranched except for the special flowering branches; leaves chartaceous or coriaceous, elliptic-lanceolate or oblanceolate, acute or acuminate, 6 to 20 cm long, 2 to 4 cm wide, generally crisped or undulate, with large albuminous marginal glands, glabrous, usually raised-punctate at least beneath, very sparingly lepidote below, the lateral nerves 12 to 18 pairs, uniting into a generally distinct marginal nerve, this sometimes hidden beneath the recurved edge; inflorescences simple or compound, subumbellate or cymose, terminal on special lateral or axillary branches about 10 cm long, these sometimes up to 16 cm long or longer, bearing a few leaves generally only at or near the curved apex, but sometimes scattered, glabrous; flowers white or pink, 4 to 6 mm long, the sepals 1.5 mm long, oblong-ovate, rounded or obtuse, scattered-punctate, the anthers distinctly punctate on back; fruit 5 to 8 mm in diameter, punctate.

Japan to southern continental Asia.

PALEOBOTANY.—*Some American fossil plants belonging to the Isoetales.*[1] Roland W. Brown, U. S. Geological Survey.

In 1889 Lester F. Ward[2] described at length but did not name some sunflowerlike rosettes from two localities in the Fort Union formation (early Tertiary) along the Yellowstone River, respectively 12 miles above and 28 miles below Glendive, Mont. In *The synopsis of the flora of the Laramie group* published in 1886, he had already alluded to these fossils as "singular cryptogams." Not, however, until 1915, in *Glimpses of the Cosmos,* a posthumous volume, did he name them *Xantholithes propheticus.*

The general superficial appearance of the more perfect of these specimens is that of a flower having numerous long, narrow rays attached to a small circular center, the whole sometimes attaining a diameter of 30 cm. The rays are 2 to 3 mm in width for most of

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[1] Published by permission of the Director, Geological Survey, Department of the Interior. Received March 1, 1939.

[2] Ward, Lester F. *Remarks on an undescribed vegetable organism from the Fort Union group of Montana.* Amer. Assoc. Adv. Sci. Proc. **37:** 199–201. 1889.

their length but terminate in a spatulate, blunt-pointed expansion. The particular feature that immediately arouses special interest is the presence of two parallel, closely-spaced rows of squarish cavities or protuberances, depending on the specimen, through the middle of the spatulate expansion and for some distance in the remainder of the ray. Ward reported these squarish outlines as being arranged in pairs; but examination of numerous specimens shows that alternations are not rare. The spatulate end of the ray has a smooth, lateral flange, which, along the narrower portion toward the base of the ray, becomes an undulate ribbon or ruffle. Because portions of the rock matrix remained in the depressions of the undulations of this ruffle when the specimen was uncovered, the ruffle appears broken, and Ward supposed that the margin of the ray was toothed. In the specimens seen by Ward the margin is entire; but a Cretaceous species I collected just east of the ghost town of Cumberland, Wyo., during the field season of 1938, has a serrate margin around the spatulate end of the ray. In regard to the surface pattern, Ward reported that "examination with a high power reveals the presence of a continuous epidermal membrane composed of hexagonal cells." Fig. 4 shows the surface pattern magnified 13 times, but the cells are square to rectangular, not hexagonal.

In order to determine the affinities of this organism Ward sought the opinion of many eminent paleontologists, botanists, and zoologists, with no very definite results, some even suggesting the possibility that the fossils might represent an animal, not a plant. The latter supposition is not altogether fantastic when viewed in the light of remarkable coincidences or resemblances. Thus, in 1900 John M. Clarke[3] described a marine organism from the Devonian of western New York as *Paropsonema cryptophya*, a supposed echinoderm. Clarke's figures are, however, not so suggestive as they might be if they illustrated U. S. National Museum specimen 62948 taken from the Ithaca member of the Portage group (Upper Devonian) in the excavation for the library at Cornell University. This almost perfect specimen is so much like the rosettes here being discussed that, did the specimens not occur in totally different environments and at widely separated moments of geologic time, they might, on hasty or superficial examination, well be confused.

Ward, however, himself concluded:

> I am disposed to regard it as a "comprehensive type" of vascular crypto-

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[3] Clarke, John M. *Paropsonema cryptophya, a peculiar echinoderm from the intumescens zone (Portage beds) of western New York.* New York State Mus. Bull. **39**: 172–186, pls. 5–9. 1900.

> gamic life, embodying some of the characters of several well-known living types, viz., 1. The large tufted central base is suggestive of most species of *Isoetes*, and the long weak stems [rays] of certain of these species are observed to recline and lie prostrate in all directions around this center. 2. The double row of spore-cases [median cavities] at the apex of the stem [ray] agrees in all essential respects with that of *Ophioglossum*, and the elliptic expansions may be regarded as homologues of the larger blade-like fronds of that genus, which may easily be imagined to have the spores borne along its median line instead of on a special fruiting frond. 3. The prostrate sinuous habit is not widely unlike that of certain creeping species of *Lycopodium* . . . . 4. A still further approach is seen in *Selaginella* where the scales have become distichous and the stems flat and closely creeping . . . . 5. Finally, ignoring the appendicular organs of *Marsilia*, we see in the fruit-bearing portion a further analogy to our fossil, the fruiting stems [rays] radiating from the thickened base and bearing the spores at their apex. The fossil would thus represent a highly generalized type and may be phylogenetically related to all these more specialized modern forms with each of which it seems to possess some characters in common.

In his reply dated August 2, 1888, to Ward's request for suggestions as to the affinities of this organism, Leo Lesquereux made two penetrating observations. First, the organism looked like that described by J. W. Dawson in 1883 as *Carpolithes horridus*. Second, the long slender "branches" are "peculiar organs of floating plants." Coming close to the latter idea also was the reply by W. G. Farlow, dated July 31, 1888, who inquired, "Have you considered the possibility of it being a whorl of inflated leaves like those of the upper portions of some Utriculariae?"

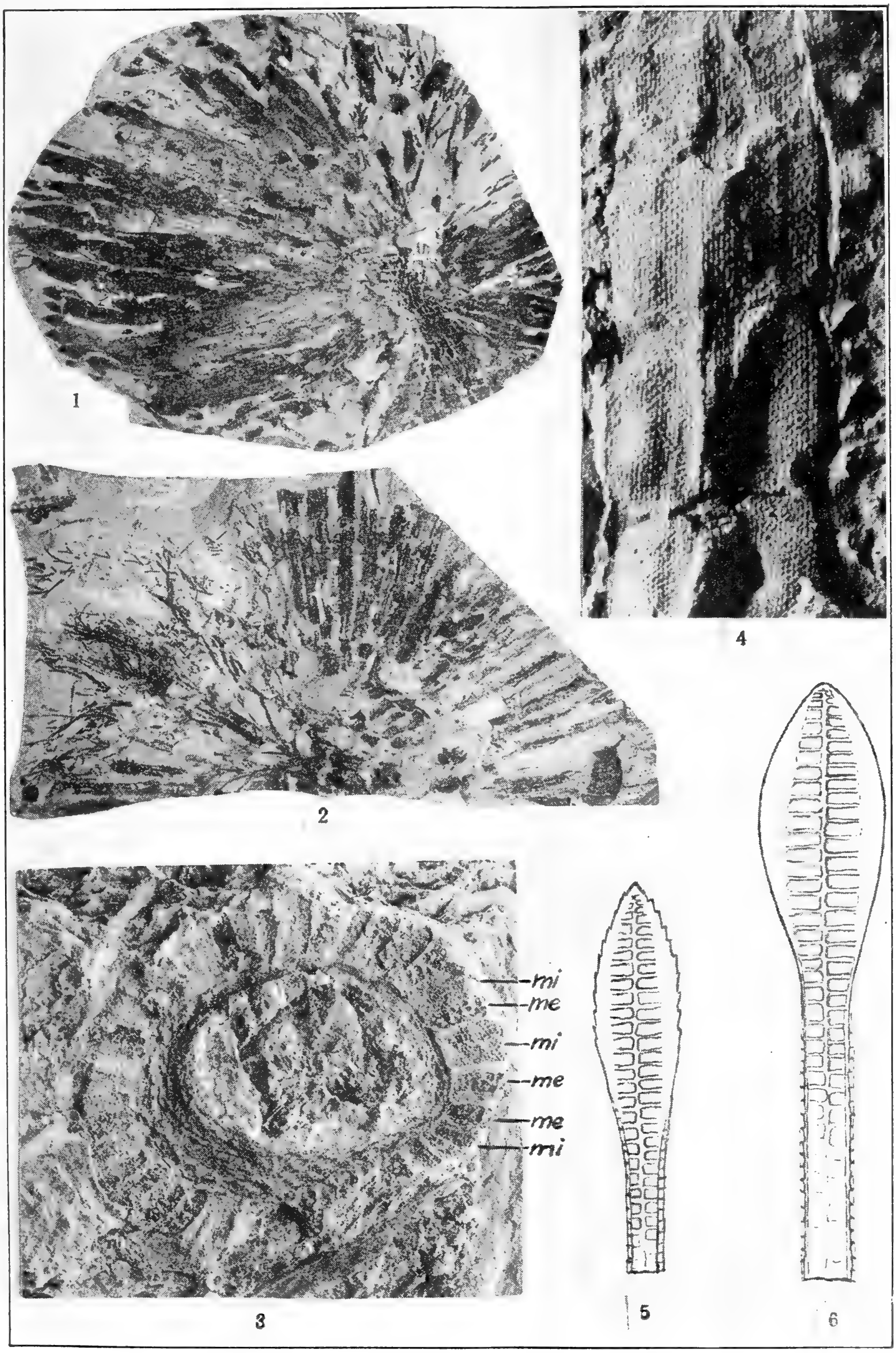
Dawson conjectured that his specimen, described and figured in 1883 as from Cretaceous strata on the Peace River in northeastern British Columbia, was a "compound fruit perhaps of some cycadaceous plant, covered with bracts and rudimentary leaves." The figure, if faithfully drawn, represents an imperfect specimen, showing none of the spatulate ends of the rays. In 1886 Dawson renamed his original specimen *Antholithes horridus* and reported additional fragmentary material from Cretaceous strata [Kootanie series, according to Dawson] on Old Man River, southwestern Alberta. He reiterated their reference to the Cycadaceae.

Ward never published an illustration of *Xantholithes propheticus;* but this lack was met by Knowlton in 1923, Cockerell in 1924, and Berry in 1935 (see synonymy of *Isoetites horridus* for references). Knowlton was concerned with a specimen from the Green River formation (middle Eocene) in Colorado, which he confidently referred to *Danaea*. That specimen is a fragment; consequently, when Cockerell in 1924 described a better specimen from the Wind River Basin of Wyoming as an *Ophioglossum*, Knowlton began to have doubts about his specimen being a *Danaea,* and agreed with Berry, who in the meantime had received additional material from Wyoming, that none of these specimens were *Ophioglossum* but were probably related to Ward's *Xantholithes propheticus* from the Fort Union formation. However, in a letter dated December 15, 1924, Knowlton remarked to Berry that, because his fragment of *Danaea* lacked the prominent flange displayed by the terminal portions of Ward's *Xantholithes propheticus,* it was likely that his *Danaea* was after all a different thing. In 1930 Berry reviewed the whole matter, calling all the Wyoming and Colorado material simply "sporophylls" and suggesting that these organisms "might represent a relict form of some member of the Williamsoniales." In 1934 I also reviewed the situation insofar as it concerned the *Danaea* specimen from the Green River formation and suggested that it be considered tentatively as distinct. With most of the specimens referred to in the discussion up to this point before me and with new collections made during the past few years of field work in Montana, Wyoming, and Colorado, I am now of the opinion that all these organisms are congeneric and represent species belonging to the Isoetales. The basis for this opinion will be apparent after considering the evidence derived from a reexamination of some features of the specimens and bringing all information about these organisms up to date.

The epidermal pattern of rectangular cells covers the entire surface of the rays uniformly; that is, it may be observed not only on the smooth surface but in the median depressions and protuberances of the "spore cases" and the undulations of the marginal ruffles as well (Fig. 4). If the median squarish outlines were indeed spore cases, these areas should display a somewhat broken or heterogeneous surface; but this is not the case; the surface is a homogeneous pattern throughout. I conclude, therefore, that these rays were leaves with crispate or wavy membranous margins in the basal portions and with midsections that carried a double row of undulations that may have been sharp wrinkles or the external outlines of internal air sacs, which, on fossilization, collapsed, leaving a series of squarish cavities.

Figs. 1, 2, 4, 5.—*Isoetites serratus* Brown, n. sp. Figs. 1 and 2 show dichotomous roots beneath the rosettes of leaves. Fig. 4 shows the surface pattern of a leaf, ×13. Fig. 5 is the spatulate end of a leaf showing the serrate margin, the ruffled, membranous, lower margin and the parallel rows of median squarish depressions, ×2. From the Frontier formation (Upper Cretaceous), 1 mile east of Cumberland, Wyo.

Figs. 3, 6.—*Isoetites horridus* (Dawson) Brown, n. comb. Fig. 3 shows a section of the corm, a set of spirally arranged leaf scars, and a circle of sporangia, *mi* (microsporangia), *me* (megasporangia), at the bases of an outer whorl of leaves, ×3. From the Fort Union formation (early Tertiary) on Poison Spider Creek, 35 miles west of Casper, Wyo. Fig. 6 is the spatulate end of a leaf showing the entire margin, ×2. From the Fort Union formation on the Yellowstone River at Burns Ranch, Mont.



Figs. 1–6.—(See opposite page for description.)

It should be noted that the outside margins of these median undulations are not so sharp as those on the inside but generally fade imperceptibly into the broad marginal flange. There is no trace of venation in these leaves, except for a thickened median line that may have been a structure analogous to a midrib. Transverse to this "midrib," especially in the proximad portion of the leaf, are scattered bars that may have been internal septa.

The plant with its radial arrangement of leaves constituted either a floating rosette or one that was close to the soil or mud in a well-watered situation. In the specimens (Figs. 1, 2) from the base of the Frontier formation in Wyoming I found immediately beneath the rosette a radiating system of dichotomous, filiform organs that appear to have been roots. The leaves of the rosette were attached spirally to a very much shortened, thick, upper portion of a stem or corm. This is clearly shown in a specimen (Fig. 3) which I collected in 1936, together with much material of the separate, broken leaves, from the Fort Union formation on Poison Spider Creek, 35 miles west of Casper, Wyo. At Burns Ranch, Mont., *Xantholithes propheticus* is associated on the same slabs of rock with *Trapa*? *microphylla* Lesquereux, a hydrophyte with a floating rosette and submerged, fimbriate, filiform leaves, anchored by a threadlike stem or root.[4]

Finally, the specimen (Fig. 3) from Poison Spider Creek also fortunately preserves the clue to the identity of all these specimens. At the bases of the leaves are elliptic bodies of two kinds, one filled with large cavities (*me*) that were once occupied by rounded objects having ridges and a variety of surface sculpture, the other filled with cavities (*mi*) only one-third or one-fourth the size of the former and once filled with rounded objects that appear to have been comparatively smooth. The comparison of these elliptic bodies and their contents with the sporangia and the megaspores and microspores of *Isoetes* is obvious and is strengthened when the entire anatomy of the fossils and their habit are compared with those of *Isoetes*.

The interested reader will find a detailed discussion of the quillworts, *Isoetes*, in Pfeiffer[5] and Clute.[6] It will be sufficient for the present purpose to cite only the facts that may apply to the specimens under discussion.

Isoetes is essentially a rosette of numerous, short, rushlike, pointed

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[4] BROWN, ROLAND W., and HOULDSWORTH, EDGAR. *The fruit of Trapa? microphylla Lesquereux.* This JOURNAL **29**: 36–39, figs. 1–9. 1939.

[5] PFEIFFER, NORMA. *Monograph of the Isoetaceae.* Ann. Missouri Bot. Gard. **9**: 79–232. 1922.

[6] CLUTE, WILLARD N. *The fern allies.* New York 1905.

leaves, with sporangia in their axils, attached spirally to a very compact 2- or 3-lobed corm from the hollows of which arise many dichotomously branched roots. A single collateral bundle runs through the center of the leaf, and this, together with some surrounding tissue, separates the hollow interior into four parallel chambers having many cross partitions. Proximad the leaves have membranous margins, and on the inner face near the base they carry a little flap of tissue called a ligule. The surface pattern is a homogeneous fabric of rectangular cells. Only the outer, earlier whorls of leaves produce sporangia, the outermost producing megaspores, the inner, microspores. Both are produced on the same plant, but in some species at different seasons. The megaspores can be seen with the naked eye, but they are generally 10 to 20 times larger than the microspores. The megaspores are white, divided equatorially by a ridge into two hemispheres, one of which is no farther divided, but the other is divided by ridges into three nearly equal triangular areas. The surface is variously patterned with spines, tubercles, pits, and serpentine forms, affording important features for specific identification. The microspores are somewhat irregularly oblong and have a smooth or slightly roughish surface. There are about 50 species of *Isoetes*, with representatives in most parts of the world, but in general each species is remarkably restricted. So far as habitat is concerned, they are classed as submerged, amphibious, and terrestrial.

By comparison with the data just given, the fossils differ from all living species of *Isoetes* in the following particulars: (1) The megaspores are only 3 or 4 times the size of the microspores, unless the objects here called microspores are immature megaspores. (2) The leaves terminate in spatulate ends, with or without serrate margins. (3) As the specimens showing sporangia are fragmentary at the point where ligules should be looked for, nothing is definite as to the presence or absence of a ligule. (4) The outline of the cross section of the corm, although somewhat irregular, shows no lobing.

Fossils most similar to the American specimens have been described by Saporta[7] from the Lower Cretaceous of Portugal as *Isoetes choffati*, now called *Isoetites choffati* (Saporta) Seward.[8] Reviewing the fossil Isoetaceae, Seward remarked that "if Saporta's . . . species . . . is correctly determined, it is the oldest fossil member of the family and indeed the most satisfactory among the more than doubtful species

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[7] SAPORTA, LE MARQUIS DE. *Flore fossile du Portugal.* Direct. Trav. Geol. Portugal, p. 134, pl. 24, fig. 2b, 9–11; pl. 25, figs. 5–8; pl. 27, fig. 6, 1894.

[8] SEWARD, A. C. *Fossil plants* **2**: 66–68. 1910.

described as extinct species of *Isoetes*. . . . Such evidence as we have lends support to the inclusion of these Portuguese fossils in the genus *Isoetes*, but apart from the fact that we have no proof of any connexion between the stems and supposed sporophylls, the resemblance of the latter to those of *Isoetes* is, perhaps, hardly sufficient to satisfy all reasonable scepticism. . . . ." It is hoped that the skepticism, avowed by Seward in regard to Saporta's Portuguese specimens, may now be removed by the evidence supplied from the American specimens reported here. As regards Saporta's *Isoetopsis subaphylla* from the Eocene of Aix-en-Provence, continued doubt as to its relationship with the Isoetaceae must be entertained.

Although not founded upon very satisfactory material, the genus *Isoetites* Münster seems to have precedence and to be most appropriate for the fossils here under consideration. I distinguish two American species: *Isoetites serratus* Brown, with spatulate leaf ends having serrate margins, and *Isoetites horridus* (Dawson) Brown, with spatulate leaf ends having entire margins.

To E. W. Berry and W. R. Maxon I am grateful for specimens and an exchange of ideas concerning these fossils.

All specimens figured here are in the U. S. National Museum.

Isoetites serratus Brown, n. sp. Figs. 1, 2, 4, 5

Rosettes of narrow, strap-shaped leaves with spatulate ends having a serrate margin. The margin of the narrow portion of the leaves is entire, membranous, and ruffled. The median line of the leaves is marked by two parallel, closely spaced rows of squarish cavities or protuberances, depending on the specimen. Immediately beneath the rosette of leaves is a radiating system of dichotomously branched roots. The leaves and roots are attached to a rounded, compact corm.

This species differs from *Isoetites horridus* (Dawson) Brown chiefly in having a serrate margin around the spatulate ends of the leaves. Whether some other Cretaceous specimens now synonymized with *I. horridus* should be included with *I. serratus* is a question that can be decided only when better-preserved material from those localities is found.

Occurrence.—Base of the Frontier formation (Upper Cretaceous), in shales weathering white, exposed in a bluff on the south side of Little Muddy Creek, 1 mile east of Cumberland, Wyo. (Figs. 1, 2, 4, 5).

Isoetites horridus (Dawson) Brown, n. comb. Figs. 3, 6

Carpolithes horridus Dawson, Roy. Soc. Canada Trans. **1** (sec. 4): 21, pl. 1, figs. 3, 3a, 36. 1883.

Antholithes horridus (Dawson) Dawson, idem. **3** (sec. 4): 7. 1886.

Vegetable organism, Ward, Amer. Assoc. Adv. Sci. Proc. **37**: 199–201 1889.— Idem, 6th Ann. Rept. U. S. Geol. Surv.: 534, 544. 1886.

Xantholithes propheticus Ward, *Glimpses of the Cosmos*, p. 150. 1915.—Berry, Geol. Surv. Canada Mem. **182:** 65, pl. 20. 1935.
Williamsonia marylandica Berry, *Upper Cretaceous*, Maryland Geol. Survey, p. 769, p. 51, figs. 5, 6. 1916.
Danaea coloradensis Knowlton, U. S. Geol. Surv. Prof. Paper **131:** 150, pl. 36, fig. 4. 1923.—Berry, Torreya **24:** 49. 1924.—Brown, U. S. Geol. Surv. Prof. Paper **185**–C: 52. 1934.
Ophioglossum hastatiforme Cockerell, Torreya **24:** 10, with text fig. 1924.
Xantholithes hastatiformis Cockerell, Torreya **26:** 10. 1926.
Sporophylls, Berry, U. S. Geol. Surv. Prof. Paper **165:** 78. 1930.

This species is morphologically similar to *Isoetites serratus* Brown, except that it appears to be represented by larger specimens and has entire margins around the spatulate ends of the leaves. The specimens from Poison Spider Creek, Wyo., in addition show sporangia in the axils of the leaves, the only American examples so far reported. These are similar to *Isoetites choffati* (Saporta) Seward from Portugal, but as the latter species is not represented by specimens showing the character of the leaf ends, it is not possible to make further comparisons between it and the American species.

It may be that I have included in the synonymy some names attached to fragmentary material which when better material from the same localities or formations is found may necessitate some reallocations. In the meantime the books will be cleared of a number of names now given to several incomplete specimens.

Occurrence.—In Cretaceous (according to Dawson), on forks of Pine River and Peace River, British Columbia; Kootanie series (according to Dawson), on middle branch of north fork of Old Man River, southwestern Alberta; Mentor formation (Lower Cretaceous), 8 miles south of Hanston, Hodgeman County, Kans.; Magothy formation (Upper Cretaceous), Little Round Bay, Anne Arundel County, Md.; Tullock formation (early Tertiary), on Moon Creek, 10 miles west of Miles City, Mont.; in carbonaceous shales (early Tertiary) in North Dakota, 3 miles north of Watauga, South Dakota; Fort Union formation (early Tertiary), on Poison Spider Creek, 35 miles west of Casper, Wyo. (Fig. 3); idem, west flank of Cedar Creek anticline, 12 miles southwest of Glendive, Mont.; idem, left bank of Yellowstone River at Burns Ranch, 28 miles northeast of Glendive, Mont. (Fig. 6); Ravenscrag formation (early Tertiary), northwest sec. 35, T. 5, R. 1 W. of 3d meridian, Saskatchewan; probably Wasatch formation (Eocene), southwest $\frac{1}{4}$ sec. 18, T. 6 N., R. 4 W., north of Tipperary, Wyo.; Green River formation (middle Eocene), Rio Blanco County, Colo.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BOTANICAL SOCIETY

290TH MEETING

The 290th regular meeting was held May 3, 1938, in the assembly hall of the Cosmos Club, President GRAVATT presiding; attendance 85. MORRIS A. HUBERMAN was elected to membership.

Notes and Reviews.—M. C. MERRILL called attention to the Boysen berry, which was advertised as being adapted to Eastern United States. Kenneth Raper called attention to the program of the Virginia Academy of Sciences being held May 5, 6, and 7 at Blacksburg, Va.

Program.—WALTER T. SWINGLE: *New methods utilized in studying the taxonomy of the orange subfamily.* (Albert H. Tellison demonstrated microtome sections of flowers from herbarium material.) In 1918 Prof. H. O. Juel, of the University of Uppsala, Sweden, published a taxonomic study of the plant family Rosaceae. He had to use herbarium material for some of the genera and devised a method of restoring dried flowers and young fruits by softening them, first in hot water, then in hot dilute ammonia. This material was then dehydrated, imbedded in paraffin, and cut into serial microtome sections.

With the skilled assistance of A. H. Tillson, Dr. Swingle has used Juel's method with good results in a taxonomic study of *Citrus* and related genera. Some 150,000 serial sections were made, mostly from herbarium material. Juel's method has been improved in some details; for instance, by treating the softened and swollen material with a suitable fixative before dehydrating it. Very hard material was desilicified and softened by treating carefully with the proper strength of hydrofluoric acid, which has been used so effectively by Prof. E. C. Jeffrey. All these treatments were carried out in such a manner as to permit the best and most brilliant double staining of the tissues. This improved method made it possible to work out a new classification of the orange subfamily Aurantioideae and to add several new genera and a few new subtribes that permit a natural arrangement of all the genera.

Lantern slides were shown of longitudinal and cross sections of flower buds, flowers, and young fruits taken from herbarium specimens. Doubled-stained permanently mounted microtome sections of such material were demonstrated with a compound microscope.

HAIG DERMEN: *Cytological analysis of polyploidy induced by colchicine and extremes of temperature.* The methods of inducing polyploidy in the meiotic and somatic cells of *Rhoeo discolor* with colchicine and temperature changes were described. Gross and cytological observations were presented concerning somatic changes brought about by colchicine treatment of the *Rhoeo* flower parts. It was found that colchicine enters tissues and inhibits cell division, while the nucleus and cell volume may increase, presumably, as long as colchicine is present in sufficient quantity to be effective until such an increase is checked by some other factors.

Colchicine is effective on both premeiotic and meiotic cells. Pollen mother cells derived from affected premeiotic tissue may be 4n, 8n, or higher, depending upon how young the treated buds were at the time colchicine was applied and how many times division in the premeiotic cells has previously failed before being differentiated into meiotic cells. By affecting normal pollen mother cells, either diploid pollen grains are produced if the effect of colchicine is after reductional division or tetraploid pollen grains if the effect is before reductional division. The treatment was apparently ineffective in causing chromosome doubling in microspores.

The immediate result of temperature treatments was the same as that of colchicine. However, it was shown that the effect of temperature changes is immediate and not extended, as is usually the case with colchicine. Here lies the most important difference in the effects of these two methods. It was suggested that temperature effect may be more specific on chromosomes, while colchicine effect may be more specific on cytoplasm.

Evidence was presented to account for the fact that by temperature-treatment the percentage of polyploid seeds in heat-treated material is small, and an attempt was made to account for the rarity of polyploidy occurring in nature.

In temperature-treated material, fragmentation, fusion, and chromatin bridging occurred. It was suggested that clumping brought about by temperature treatment is responsible for these features.

Some suggestions were presented for plant breeders who are interested in doing experiments in polyploidy.

ERIC HULTEN (Curator of Herbarium, Lund, Sweden): *Flora of Alaska.*

291ST MEETING

The 291st meeting was held October 4, 1938, in the assembly hall of the Cosmos Club; President GRAVATT presiding; attendance 90.

Notes and Reviews.—M. B. WAITE exhibited seeds from bamboos growing at Stony Run near Baltimore. He also stated there was a large crop of persimmons this year although other fruit crops were small. The persimmon blooms in June. It ripened in September in southern Maryland one month before frost.

Frank Thone exhibited several new books: *Herbals*, by Agnes Arber; *The world was my garden—Travels of a plant explorer*, by David Fairchild; *Textbook of general botany*, by Hollman and Robbins; *Ferns of Southeastern States*, by John Kunkel Small; *Tree growth*, by D. T. MacDougal; *Flora of Costa Rica*, publication of the Field Museum; *Famous trees*, a U. S. Department of Agriculture publication; *Textbook of pharmaceutical botany*, by H. W. Younker.

Program.—WILLIAM A. DAYTON: *Ecology of western range plants.* The U. S. Forest Service is primarily concerned with a multiple-use land problem, in which forest, range, wildlife, recreation, water, sociological, and other phases must be correlated and integrated. Nearly 40 percent of the land area of the United States (728 million acres) is in range, of which about 90 million acres are in national forests. Forest Service range research is chiefly concentrated at six forest and range experiment stations. Range vegetation is chiefly composed of over 10,000 species of flowering plants, about 1,000 of which are "key" plants, on which adequate range management must primarily depend. The approach to their study is an ecological one. Published research on range plants, in addition to the strictly economic phases, physiology and chemistry, thus far largely concerns succession, methods of reproduction, life history, indicator values, and reaction to biotic factors. Use of the quadrat to help solve land-management problems appears to have been initiated in 1907 in range studies on the Wallowa National Forest, Oregon.

L. F. MARTIN: *Proteins in healthy and mosaic tobacco.* Developments in plant virus investigations leading to the isolation of paracrystalline and crystalline virus nucleoproteins were reviewed briefly. The problem of virus multiplication has thus become a problem of protein synthesis. The nature of this synthesis is still obscure, as revealed by recent speculations of Bergmann on the "organizer hypothesis" and his suggestion that all proteins are their own organizers.

The unusual resistance of native virus nucleoprotein to tryptic digestion makes it possible to estimate the amount of this substance in whole plant tissue, and to determine its rate of synthesis and relation to the normal protein fraction. Results of a preliminary study of the changes during the course of infection show that displacement of normal proteins by virus protein occurs only during the first three to five days after inoculation. Following this there is a very rapid accumulation of virus protein, accompanied by increased production of total proteins, so that the virus protein is present in excess of the normal proteins. During the later stages until maturity the amount of virus protein diminishes gradually. Further work along these lines is required to explain the mechanism of these changes involved in the production of virus in the host.

G. R. FESSENDEN: *Preservation of plant color in plant specimens.* This process has been in development for 13 years and is still not yet out of the experimental stage. It consists essentially in immersing fresh plant material in complex viscous mixtures, which tend to set pigment colors and fix tissues, at the same time removing cell-sap. A wide range of formula modification is necessitated by individual biochemical differences of various types of plants. When pigments and tissues have thus been preserved, specimens are sealed between cellulose films (or between glass and film) so as to be protected from mechanical injury and damage from insects or mold. Mounts are provided with backgrounds that may be hinged to allow viewing of both sides.

Specimens thus preserved and mounted are suited for museum display; herbarium reference use; agricultural records and demonstrations (especially for plant breeding, pathological conditions, and nutritional deficiencies); educational use in class rooms and libraries; horticultural exhibits; plant exploration.

ALICE M. ANDERSEN, *Secretary*

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JOURNAL
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VOL. 29 JULY 15, 1939 No. 7

PALEONTOLOGY.—*A further contribution to the Dragon Paleocene fauna of central Utah.*[1] C. LEWIS GAZIN, U. S. National Museum.

Additional material of Paleocene Mammalia from the upper portion of the North Horn formation in central Utah was obtained by the 1938 Smithsonian Institution expedition in search of fossil vertebrates. The greater part of the collection was made from deposits of limited exposure in Dragon Canyon, in the western half of section 8, T. 19 S., R. 6 E. A few specimens were collected at a locality on the south end of Wagon Road Ridge to the west of Dragon Canyon and at a much higher elevation. The North Horn formation, together with the capping Flagstaff limestone and the older rocks, is much faulted in this region, and the Paleocene deposits in Dragon Canyon are a part of a depressed block separated by one or more north-south striking faults from the higher standing rocks of Paleocene age in the mountainous masses to the east and to the west.

The new materials collected during the 1938 season show the Dragon fauna to be more varied than had been recognized from the less extensive, though important, collection made in 1937. The specimens so far found are more fragmentary than the average of those coming from the better known deposits in the San Juan Basin and Crazy Mountain fields. In addition to crocodile and champsosaurid remains, the collection now includes material representing about 19 mammalian forms, of these 9 are recognized as new species, and three new genera are proposed. The following is a list of the Mammalia:

MULTITUBERCULATA:
  Catopsalis utahensis, n. sp.
  Ptilodus sp.

INSECTIVORA:
  Aphronorus simpsoni Gazin
  Insectivore? gen. and sp. undet.

PRIMATES?:
  Primate? gen. and sp. undet.

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[1] Published by permission of the Secretary, Smithsonian Institution. Received March 1, 1939.

TAENIODONTA:
- *Conoryctella dragonensis*, n. gen. and sp.

CARNIVORA:
- *Protogonodon*? *spiekeri* Gazin
- *Oxyclaenus*? sp.
- Oxyclaenid near *Tricentes*
- *Didymictis*? sp.

TALIGRADA:
- *Periptychus gilmorei* Gazin
- *Anisonchus dracus*, n. sp.
- *Anisonchus onostus*, n. sp.
- *Haploconus inopinatus*, n. sp.

CONDYLARTHRA:
- *Dracoclaenus griphus*, n. gen. and sp.
- *Ellipsodon shepherdi*, n. sp.
- *Ellipsodon*? *sternbergi*, n. sp.
- *Ellipsodon*? sp.
- *Jepsenia mantiensis*, n. gen. and sp.

Most of the above forms are rather sparsely represented, the Condylarthra including the more common forms. Material of *Ellipsodon* and of the new group *Dracoclaenus* is relatively most abundant, although that of periptychids, especially *Periptychus gilmorei*, is not uncommon.

The intermediate character of the fauna between that of the Puerco and that of the Torrejon, previously noted in the relationships of *Periptychus gilmorei* and of *Protogonodon*? *spiekeri*, is further indicated in the relationships of *Conoryctella dragonensis* and of *Anisonchus dracus*. These have related types in both the Puerco and Torrejon faunas. The remaining forms in the Dragon fauna either do not have comparable types in one or the other of the two San Juan horizons or the material is too fragmentary to permit more than the most casual comparisons. Five of the forms listed—*Catopsalis*, *Ptilodus*, *Aphronorus*, *Didymictis*, and *Haploconus*—suggest in name a closer approach to the Torrejon stage. Such may be the case; however, since the ancestry of these forms in the Puerco horizon is not known, the relative position in time which they suggest is doubtful. The problems of each of the forms will be discussed under their respective headings.

I wish to acknowledge the courtesy extended by Dr. Walter Granger in permitting comparisons with Paleocene materials in the American Museum of Natural History and by Dr. Glenn L. Jepsen, of Princeton University, in permitting me to examine Paleocene materials from the Big Horn Basin. The drawings illustrating certain of the Dragon specimens were made by Sydney Prentice.

SYSTEMATIC DESCRIPTION OF THE MATERIAL

MULTITUBERCULATA

Catopsalis utahensis, n. sp.

Type.—Left M_1, U.S.N.M. no. 15757.

Horizon and locality.—Dragon Paleocene, Dragon Canyon, Emery County, Utah.

Specific characters.—Cusp formula: M_1 6:4. Length of M_1 approximately 12 mm. Width 6.5 mm.

Description.—A single first lower molar is recognized as representing a taeniolabid multituberculate. The tooth exhibits the simple type of pattern seen in *Catopsalis* from the Torrejon rather than the more specialized dental structure of the Puerco *Taeniolabis.* It differs from species of *Catopsalis* known from the Torrejon of the San Juan Basin in the cusp formula of M_1. In *Catopsalis foliatus* it is 5:4, and in *C. fissidens* the formula is 6:5 or better. Moreover, the tooth appears relatively wider than in either of the Torrejon species. *C. calgariensis* Russell from the Paskapoo was described from a second lower molar; hence no satisfactory comparison is possible.

The relative position in time of the genera *Taeniolabis* and *Catopsalis,* as pointed out by Granger and Simpson, appears paradoxical; consequently one should expect to find, eventually, other taeniolabids representing ancestral stages of *Catopsalis* in beds earlier than Torrejon. The single tooth of *C. utahensis* does not seem to present any significant evidence as to ancestral stages in the development of the genus *Catopsalis,* but appears only to extend its known geologic range to a somewhat earlier part of the Paleocene.

Ptilodus sp.

A lower jaw fragment, U.S.N.M. no. 15730, including the basal portion of the incisor and the anterior part of P_4 is considered to represent *Ptilodus,* a conclusion in which Dr. G. L. Jepsen of Princeton University concurs. The material is too incomplete to permit specific comparisons, but the specimen indicates an animal not greatly different in size from *Ptilodus mediaevus* of the Torrejon.

Material of *Ptilodus* is not known elsewhere in beds earlier than Torrejon; hence a consideration of the development of *Ptilodus* during earlier Paleocene time remains speculative and based on what is known of related types in the Cretaceous. Here again, *vide* Granger and Simpson, the position of *Ptilodus* relative to the more specialized *Eucosmodon,* known from the Puerco as well as the Torrejon, seems capricious but indicates a diversity of phyletic lines.

INSECTIVORA

Aphronorus simpsoni Gazin

Only a few fragmentary specimens of this form were obtained by the 1938 expedition. These add little or nothing to the diagnosis made in the original description. Except for a noticeably worn upper molar, tentatively referred to this form, the material consists of lower teeth or jaw portions.

Insectivore? gen. and sp. undet.

A jaw fragment with M_3 and perhaps other isolated teeth may represent one of more Insectivora other than *Aphronorus.*

PRIMATES?

Primate? gen. and sp. undet.

In a fragment of a jaw, U.S.N.M. no. 15719, a molar tooth, M_1 or M_2, in which the crown of the trigonid is broken away, exhibits a talonid portion so closely resembling that in the Fort Union primates as to indicate strongly affinities with that group. The heel shows a wide basin with a prominent hypoconid and somewhat less important entoconid, no accessory cuspules and the posterior wall of the tooth appears only slightly convex between the two cusps. The specimen is close to *Paromomys maturus* Gidley in size but probably does not represent the same genus. The talonid portion has a width of 2 mm.

If the affinities of this very fragmentary specimen are properly understood, it represents the earliest primate known.

TAENIODONTA

Conoryctella, n. gen.

Type.—*Conoryctella dragonensis,* n. sp.

Generic characters.—Near *Conoryctes* but P^4 not molariform, tritocone (metacone) not comparable to protocone and deuterocone in development, and no indication of a metaconule. Teeth less hypsodont, cusps lower, with heavy cingulum around outer cusps of upper molars. Mesostyle less prominent. Paraconid in M_1? unreduced in a referred specimen.

Conorcytella dragonensis, n. sp. Fig. 1

Type.—Portion of left maxilla with P^4 to M^2, U.S.N.M. no. 15704.

Horizon and locality.—Dragon Paleocene, Dragon Canyon, Emery County, Utah.

Specific characters.—Smaller than *Conoryctes comma* but much larger than *Onychodectes tisonensis.*

Description.—The upper teeth, made the type of *Conoryctella dragonensis,* are only a little smaller than in *Conoryctes comma* but distinctly larger than in *Onychodectes tisonensis.* The Dragon form is about intermediate between these two species in degree of hypsodonty. P^4 is not so nearly molariform as in *C. comma* and has the lingual portion more compressed anteroposteriorly. The protocone and deuterocone are prominent conical cusps, and the tritocone, though damaged, is seen to be but weakly developed as compared to the two other cusps. The lingual portion of this tooth does not appear crescentic; nevertheless, a low crest or cingulum extends along the posterior portion between the deuterocone and tritocone.

The paracone and metacone in the first two molars, as far as preserved, are seen to be conical and low and are separated from the outer margin of the teeth by a heavy cingulum. The mesostyle, though present, is not so strongly developed as in *C. comma.* It is absent in *O. tisonensis.* The anteroexternal and posteroexternal angles of the teeth are more rounded than in *O. tisonensis* and do not exhibit styles at these points such as in the Puerco form.

The anteroposterior diameters of the upper teeth, P^4 to M^2, are approximately 7.5, 8.2, and 7.4 mm, respectively. Any transverse measurements would be highly arbitrary.

A lower jaw fragment, U.S.N.M. no. 15722, with a molar tooth, apparently M_1, may represent *Conoryctella dragonensis,* although it is from an individual somewhat smaller than the type. The tooth is about intermediate between *O. tisonensis* and *C. comma* in hypsodonty but apparently a little nearer *O. tisonensis* in size. The trigonid of the tooth possesses a moderately developed paraconid situated much as in M_1 of *O. tisonensis.* The heel or talonid, though partially obscured by matrix is relatively broad, appears to be deeply basined and to have a somewhat cuspidate crest, approaching the condition seen in *C. comma.*

The Dragon lower tooth does not exhibit the basal accessory cuspule anteroexternal to the hypocone seen in *Onychodectes rarus.*

CARNIVORA

Protogonodon? spiekeri Gazin

Only a third upper molar and a portion of a lower molar of *Protogonodon? spiekeri* were added to the collection by the 1938 expedition. The characters of these teeth were known from material collected in 1937; hence nothing new can be added to the diagnosis of this form.

Oxyclaenus? sp.

A lower jaw fragment, U.S.N.M. no. 15776, with M_2 and part of M_1, resembles closely, in the characters of M_2, a lower tooth belonging to the type *Oxyclaenus simplex* and material referred to *O. cuspidatus.* It differs from these only in having the crest connecting the paraconid and protoconid extending slightly less anteroexternally, in the absence of a very small cuspule probably unimportant, anterior to the entoconid, which tends to close the talonid basin internally in the Puerco material, and in somewhat less development of the hypoconulid. The second molar has about the proportions of the lower tooth belonging with the type of *O. simplex* and exhibits a well-marked external cingulum.

Another lower molar, no. 15784, apparently an M_1, possibly of the same form, is distinguished by having the paraconid somewhat more median in position and lacking the external cingulum.

Oxyclaenid, near **Tricentes**

An isolated upper molar, U.S.N.M. no. 15783, apparently M_1, is recognized as coming from an oxyclaenid type of creodont belonging to or near *Tricentes.* The tooth is about one-fifth smaller than in *Tricentes subtrigonus* from the Torrejon. The cusps have about the same conical appearance, and the hypocone occupies a position equivalent to that in *Tricentes;* also, the cingulum is not continuous across the buccal surface of the paracone, a condition characteristic of M^1 in *Tricentes.* However, the enamel appears less rugose than in *T. subtrigonus* and the cingulum lingually is not continuous across the protocone.

Didymictis? sp.

A fourth lower premolar, U.S.N.M. no 15763, apparently represents the genus *Didymictis.* The tooth is only slightly smaller than in *Didymictis haydenianus* from the Torrejon but does not have the first cuspule posterior to the large cusp so distinctly set off from this primary cusp. The cuspules of the talonid are more nearly in the median line of the tooth than was observed in *D. haydenianus.* The tooth is distinctly larger than in *D. microlestes* from the Crazy Mountain locality in the Fort Union of Montana.

An isolated fourth upper premolar may possibly belong to *Didymictis* but is too small to belong to the form represented by the lower tooth. Moreover, the deuterocone portion does not extend forward so markedly as in the Torrejon material of *Didymictis,* a condition suggestive of *Ictidopappus,* but the posterior cusp, though prominent, is not developed into so nearly a shearing blade as in either *Didymictis* or *Ictidopappus*.

TALIGRADA

Periptychus gilmorei Gazin

Several additional specimens of this large peritychid were obtained in 1938, the most significant being portions of the right and left rami of a lower jaw, U.S.N.M. no 15689, exhibiting P_4 to M_3. This material further warrants the conclusions drawn from the upper dentitions figured in an earlier paper. The lower teeth are also nearly intermediate in most respects between *Carsioptychus coarctatus* from the Puerco and *Periptychus carinidens* of the Torrejon. The protocone of P_4 is not directed posteriorly so markedly as in *C. coarctatus,* and a small anterointernal cusp is present, this being prominent in *P. carinidens* but usually absent in *C. coarctatus.* On the posterointernal portion of the tooth there is a small cusp; the talonid, however, is not developed so much as in *P. carinidens.* The extent to which a metaconid has become distinct from the protoconid can not be exactly determined, owing to wear, but it is clearly not separated to the extent seen in *P. carinidens.*

The lower molars are wider than in the *Carsioptychus* material at hand but not so wide as is common in Torrejon material of *Periptychus.* These teeth show a slight cingulum around the external side, which was not observed in material of the other forms. The small seventh cusp located about in the center of the crown of the lower molars of *Periptychus carinidens* is not present in the first two molars of *P. gilmorei* but is weakly developed in M_3. This cusp is not known in *Carsioptychus.*

TABLE 1.—MEASUREMENTS (IN MILLIMETERS) OF LOWER TEETH OF *Periptychus gilmorei*

	P_4	M_1	M_2	M_3
Anteroposterior diameter....................	11	10.3	10	11.5
Transverse diameter........................	9.6	8.7	9.7	9

Anisonchus dracus, n. sp. Fig. 2

Type.—Maxillary fragment with P^4 to M^3, U.S.N.M. no 15745.

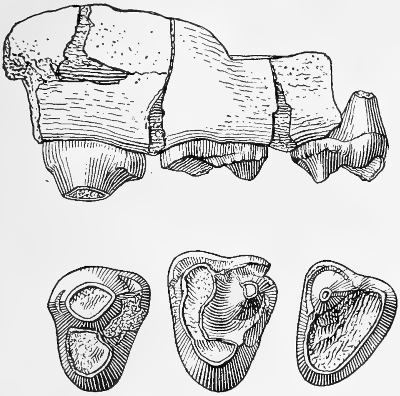
Horizon and locality.—Dragon Paleocene, Dragon Canyon, Emery County, Utah.

Specific characters.—Intermediate in position of cusps and in relative proportions of the upper cheek teeth between *Anisonchus gillianus* and *A. sectorius.*

Description.—The maxillary fragment, no. 15745, with cheek teeth P^4 to M^3 inclusive, clearly belongs to the genus *Anisonchus* and is intermediate in the observed characters between *A. gillianus* and *A. sectorius* of the Puerco and Torrejon, respectively. As has been noted in the comparisons of *Periptychus gilmorei* with comparable forms in the Puerco and Torrejon, the upper cheek teeth in the Dragon *Anisonchus* are of an intermediate character in the relation of the length to the width of the crowns.

The Dragon form approaches *A. sectorius* in size but retains relatively wider teeth transversely, and longitudinally a little shorter, and the cusp pattern is not so restricted transversely. The upper teeth appear also to have a longer, more gradually sloping lingual wall, with a somewhat more lingually placed hypocone column. The lingual portion of P^4 seems more constricted anteroposteriorly and apparently has a less conspicuously developed lingual crescent.

A. gillianus has teeth relatively wide transversely, the length of the tooth row shorter, and the hypocone is placed more lingually with respect to the metacone, and to a certain extent with respect to the protocone, than in *A. sectorius*.



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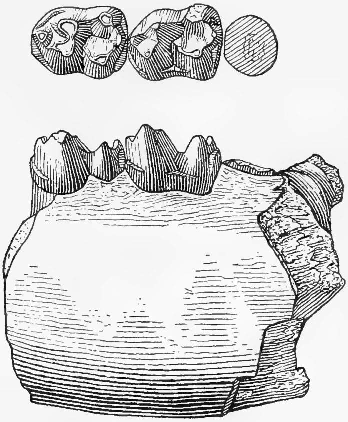

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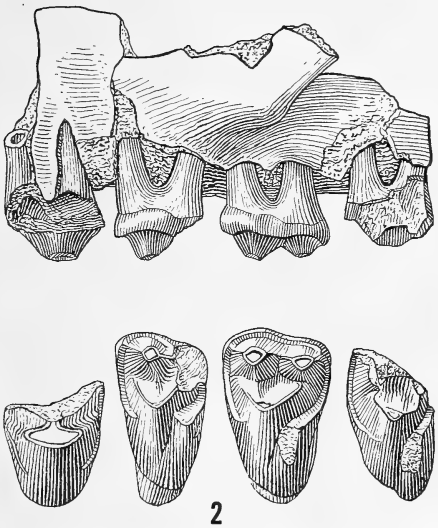

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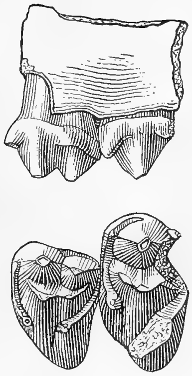

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Fig. 1.—*Conoryctella dragonensis*, n. gen. and sp. Left P^4 to M^2, type, U.S.N.M. no. 15704. Lateral and occlusal views. ×1.8. Fig. 2.—*Anisonchus dracus*, n. sp. Left P^4 to M^3, type, U.S.N.M. no. 15745. Lateral and occlusal views. ×3. Fig. 3.—*Anisonchus onostus*, n. sp. Left M_1 and M_2, type, U.S.N.M. no. 15788. Occlusal and lateral views. ×3. Fig. 4.—*Haploconus inopinatus*, n. sp. Left M^1 and M^2, type, U.S.N.M. no. 15760. Lateral and occlusal views. ×3.

Two isolated jaw fragments, U.S.N.M. nos. 15715 and 15787, each with a single molar, presumably both M_2, are nearly equal in size to *Anisonchus sectorius* and show no significant differences from either *A. sectorius* or *A. gillianus*. However, the crest connecting the hypoconid to the trigonid appears distinctly lower than that connecting the entoconid to the metaconid. This condition was noted in an M_1 of *A. gillianus* but not in other specimens of either this species or *A. sectorius*. Moreover, the hypoconulid does not project backward in the molars referred to *Anisonchus dracus* quite so far as in M_2 of *A. sectorius*, a condition approximated in M_2 of *A. gillianus*, though possibly of doubtful significance.

TABLE 2.—MEASUREMENTS (IN MILLIMETERS) OF UPPER TEETH OF *Anisonchus dracus*

	P^4	M^1	M^2	M^3
Anteroposterior diameter	5?	4.4?	4.8	4?
Greatest transverse diameter		6.6?	7.8	

Anisonchus onostus, n. sp. Fig. 3

Type.—Left ramus of mandible with M_1 and M_2, U.S.N.M. no 15788.

Horizon and locality.—Dragon Paleocene, Dragon Canyon, Emery County, Utah.

Specific characters.—Near *Anisonchus gillianus* in size. Teeth slightly lower crowned and cusps of talonids more widely spaced.

Description.—*Anisonchus onostus* is decidedly smaller than *A. dracus*, being very near the Puerco form *A. gillianus* in size but with the cusps on the talonid of both M_1 and M_2 slightly more widely spaced, though having the cut characterizing the anisonchines. This spacing of the cusps gives the teeth a somewhat wider appearance, whereas actually they are a trifle narrower than those in several specimens of *A. gillianus* with which comparisons were made. The teeth also appear somewhat lower crowned than those of *A. gillianus* exhibiting about the same wear.

The anteroposterior diameters of the first and second lower molars are 4.3 and 4.1 mm, respectively. The transverse diameters are 2.9 and 3.2 mm.

Haploconus inopinatus, n. sp. Fig. 4

Type.—Portion of left maxilla with M^1 and M^2, U.S.N.M. no. 15760.

Horizon and locality.—Dragon Paleocene, Dragon Canyon, Emery County, Utah.

Specific characters.—Size small. Second molars much wider transversely than first molars. Protostyle prominent. Slight development of metaconule.

Description.—A second genus of anisonchine periptychids is represented by a maxillary portion with M^1 and most of M^2. The form apparently represents *Haploconus* as indicated by the prominent lingual position of the hypocone. It appears in size to be close to the Torrejon material referred to *Haploconus angustus* but with the teeth relatively wider transversely and with M^2 relatively much wider than M^1. A difference in width between M^1 and M^2 was noted in certain specimens of *Haploconus* referred to *H. angustus* but apparently the difference is not so marked as in *Haploconus inopinatus*.

The two upper molars show a slight development of a metaconule, but most noticeable is the distinct protostyle that characterizes teeth in *Haploconus corniculatus*. *H. inopinatus* is much smaller than the type of *H. corniculatus*, and in the latter the upper molars appear to be relatively as well as actually much longer anteroposteriorly than in the Dragon form.

The anteroposterior diameter of the first upper molar is 4.3 mm. The greatest transverse diameters of the first and second upper molars are 6.1 and 7.1 mm, respectively.

A lower jaw portion, U.S.N.M. no. 15744, with M_1 and M_2 poorly preserved, and partially obscured by ironlike matrix, appears to represent *Haploconus* in the absence of a paraconid and in the bladelike form of the protoconid on M_1. It corresponds closely in size to the type of *Haploconus angustus*, but with M_1 narrower, particularly the anterior portion, and M_2 wider than in the Torrejon form. This suggests that the premolars in the Dragon form may not have been so robust as in the Torrejon stage.

CONDYLARTHRA

Dracoclaenus, n. gen.

Type.—*Dracoclaenus griphus*, n. sp.

Generic characters.—Near *Protoselene*, but P^4 much more inflated and with tritocone almost indistinct. Anteroexternal and posteroexternal styles on P^4 prominent. M^1 appreciably smaller than M^2. External cingulum on upper molars strong and mesostyle present though distinct from crest connecting paracone and metacone, paraconid on lower molars more lingual in position than in *Protoselene*, and in M_2 this cusp is less reduced and not placed so low. Talonid on lower molars somewhat shallower and narrower between hypoconid and entoconid.

Dracoclaenus griphus, n. sp. Figs. 5–7

Type.—Fragment of right maxilla with M^1 and M^2, U.S.N.M. no. 15789.

Horizon and locality.—Dragon Paleocene, Dragon Canyon, Emery County, Utah.

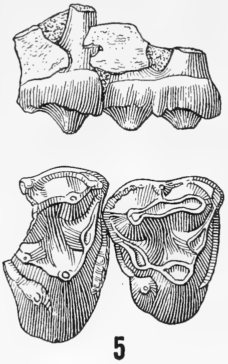
Specific characters.—Close in size to *Protoselene opisthacus.*

Description.—The material here considered to represent the new form *Dracoclaenus griphus* most closely resembles that of the Torrejon form *Protoselene opisthacus* but differs from it in several respects. A relatively large number of specimens, though fragmentary, are considered as representing this new form and three are figured and form the basis for the description.

P^4 in specimen no. 15705 is larger and more inflated than in *P. opisthacus*, approaching in this respect P^4 in *Mioclaenus turgidus*, but with less reduction of the cingulum and no metaconule such as usually present in *M. turgidus*. The tritocone of P^4 in *Dracoclaenus griphus* is almost indistinct from the protocone, whereas this tooth in *P. opisthacus* exhibits a division of the main outer cusp into a prominent protocone and a lesser tritocone placed close together. The anteroexternal and posteroexternal styles are more prominent on P^4 of the Dragon form, and a slightly better developed cingulum, though discontinuous, is indicated on the outer surface.

The upper molars, M^1 and M^2, in no. 15789 resemble closely those in *Protoselene opisthacus*, but the difference in size between these teeth is more noticeable than in the Torrejon form. The external cingulum is more prominent and more markedly crescentic about each the paracone and metacone. The mesostyle is about as well developed as in *P. opisthacus* but distinctly separated from the crest which extends between the paracone and metacone. In *P. opisthacus* the mesostyle extends outward as a spur or projection from this crest.

Another upper dentition, including P^4 to M^2, no. 15703, resembles the type in most characters of the molars but has a weaker hypocone on both molars and a very weak metaconule on M^2. The anteroexternal angle of M^2



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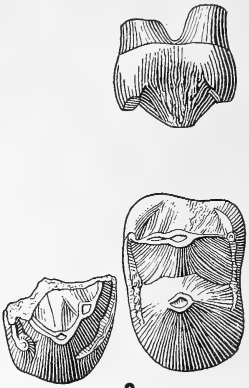

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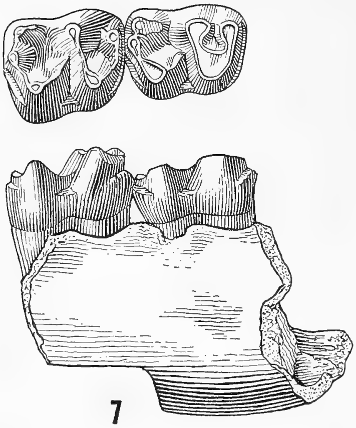

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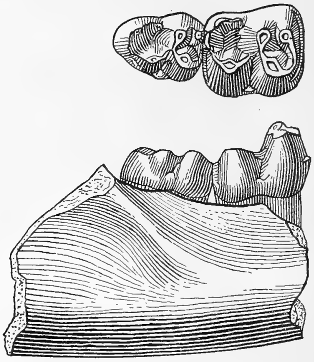

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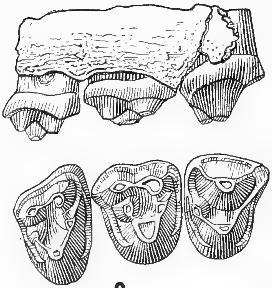

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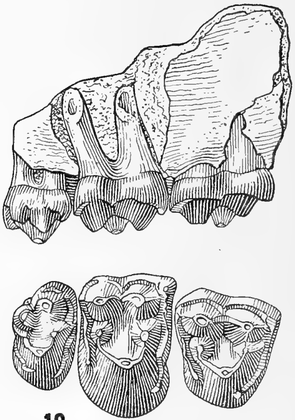

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Figs. 5–10—(See opposite page for description.)

extends forward somewhat more, suggestive of the oxyclaenids, but has the mesostyle, particularly in M^1, as in no. 15789. The external cingulum is not so crescentic around the outer cusps, the outer wall being more nearly straight. P^4 is similar but a little smaller than in nos. 15705 and 15780. This specimen, no. 15703, may represent a distinct species of *Dracoclaenus* or may possibly be of an oxyclaenid, close in size to *Oxyclaenus simplex*, however, P^4 and M^1 more closely resemble the *Dracoclaenus* material.

The lower jaw portion, no. 15773, considered by comparison to represent *Dracoclaenus griphus*, also resembles material of *Protoselene*. It corresponds closely in size to *P. opisthacus*, but has the paraconid on M_1 and M_2 more internal in position, and in M_2 it is not placed so low and is less reduced than in *P. opisthacus*. The talonid basin is apparently not so deep and is narrower between the hypoconid and entoconid. A slight accessory cusp is present on the anterior crest of the entoconid nearly as prominent as in *P. opisthacus*.

An M_3, no. 15752, in the collection, possibly belonging to this form, does not so closely resemble *P. opisthacus*. The paraconid, though low, is placed more internal than is usual in the Torrejon form. Moreover, the entoconid is not so simple as usual in *P. opisthacus*, exhibiting three small cusps in this position, and the hypoconulid is more distinctly separated from the hypoconid.

TABLE 3.—MEASUREMENTS (IN MILLIMETERS) OF UPPER TEETH, NO. 15789, AND LOWER TEETH, NO. 15773, OF *Dracoclaenus griphus*

	M^1	M^2	M_1	M_2
Anteroposterior diameter...............	5.4		5.3	5.3
Transverse diameter....................	6.4	7.5	4	4.4

Ellipsodon shepherdi, n. sp. Figs. 8–9

Type.—Right ramus of mandible with M_2 and M_3, U.S.N.M. no. 15721.

Horizon and locality.—Dragon Paleocene, Dragon Canyon, Emery County, Utah.

Specific characters.—Teeth somewhat smaller than in *Ellipsodon lemuroides* and a little larger than in *E. acolytus*. P^4 with a metaconule, distinct from cingulum. Paraconid distinct and lingually placed in M_2 and M_3. M^3 and M_3 reduced in size.

Description.—*Ellipsodon shepherdi*, as indicated by the type lower jaw, is slightly smaller than *E. lemuroides*, and the molars M_2 and M_3 are relatively narrower. M_3 is reduced to about the same extent as in *E. lemuroides*, more reduced than in the smaller forms, *E. aequidens*, *E. acolytus*, and *E. aquilonius*, but less reduced than in the Puerco species, *E. priscus*, and possibly somewhat less reduced than in the genotype, *E. inaequidens*. The paraconid of the last two lower molars is more distinct in the Dragon form than in any of the previously known species of *Ellipsodon*, much better developed

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Fig. 5.—*Dracoclaenus griphus*, n. gen. and sp. Right M^1 and M^2, type, U.S.N.M. no. 15789. Lateral and occlusal views. ×3. Fig. 6.—*Dracoclaenus griphus*, n. gen. and sp. P^4 and M^1 (part), U.S.N.M. no. 15705. Lateral and occlusal views. ×3. Fig. 7.—*Dracoclaenus griphus*, n. gen. and sp. Right M_1 and M_2, U.S.N.M. no. 15773. Occlusal and lateral views. ×3. Fig. 8.—*Ellipsodon shepherdi*, n. sp. Right M_2 and M_3, type, U.S.N.M. no. 15721. Occlusal and lateral views. ×3. Fig. 9.—*Ellipsodon shepherdi*, n. sp. Right P^4 to M^2, U.S.N.M. no. 15790. Lateral and occlusal views. ×3. Fig. 10.—*Jepsenia mantiensis*, n. gen. and sp. Right M^1 to M^3, type, U.S.N.M. no. 15747. Lateral and occlusal views. ×3.

and more lingually placed than in *E. aequidens*, but only slightly more prominent than in *E. aquilonius*. The talonids of M_2 and M_3 are more distinctly basined than in Torrejon material referred to *E. inaequidens*, but less distinctly basined than in *E. aquilonius* from Montana, also, the talonid on M_3 is better developed than in the Puerco form, *E. priscus*. Moreover, the talonid of M_2 in *E. shepherdi* does not exhibit so prominent a hypoconulid as in *E. aequidens*, but shows a more distinct entoconid than in *E. inaequidens*.

The upper teeth, P^4 to M^2, in the maxilla, U.S.N.M. no. 15790, referred to *Ellipsodon shepherdi* are relatively smaller than in the type lower jaw and approach somewhat closer to *E. acolytus* than to *E. lemuroides* in size, however, this difference within the Dragon material may not be greater than can be accounted for by individual variation.

P^4 shows a cusp in the position that would be occupied by the metaconule in the molars. This is absent in the somewhat smaller P^4 of the Puerco form, *E. priscus*, but was observed in certain specimens of the later material. P^4 is noticeably larger than in *E. aequidens*, and M^1 and M^2 are relatively longer.

An M^3 if properly referred, indicates this tooth to be more reduced than in *E. lemuroides*, and much more reduced than in *E. acolytus*, *E. aequidens*, and *E. aquilonius*.

The upper teeth do not closely resemble those in the genotype, *E. inaequidens*. The upper teeth in the latter exhibit smooth crests running to the protocone and weak or undeveloped cingula.

TABLE 4.—MEASUREMENTS (IN MILLIMETERS) OF UPPER TEETH, NO. 15790, AND LOWER TEETH, NO. 15721, OF *Ellipsodon shepherdi*

	P^4	M^1	M^2	M_2	M_3
Anteroposterior diameter................	3.7	3.9	3.6	4.4	3.8
Transverse diameter....................	4.5	4.9	5.8*	4	2.9

* Greatest transverse diameter.

Ellipsodon? sternbergi, n. sp.

Type.—Fragment of right ramus of mandible with M_3 and part of M_2, U.S.N.M. no. 15755.

Horizon and locality.—Dragon Paleocene, Dragon Canyon, Emery County, Utah.

Specific characters.—Considerably more robust than *Ellipsodon shepherdi* or *E. lemuroides* but much smaller than *Mioclaenus turgidus*. Molars simple and relatively broad. M_3 oval in shape and reduced in size.

Description.—A species nearly intermediate in size between *Ellipsodon lemuroides* and *Mioclaenus turgidus* is represented by a few fragmentary specimens, including a jaw portion with M_3 and a part of M_2, which is made the type of *Ellipsodon sternbergi*. M_2 is much larger and broader than in other species of *Ellipsodon;* however, it apparently shows no crenulation of the crest around the posterointernal margin of the talonid as seen in many of, though not all, the lower dentitions of *M. turgidus*. The paraconid is only weakly developed on a referred M_2, which has this portion of the tooth preserved. M_3 is only a little larger than in *Ellipsodon shepherdi* and somewhat more rounded, being nearly oval in shape. The paraconid is lacking on M_3 with only a low crest extending across the front of the tooth, connecting the protoconid and metaconid. Though reduced, the paraconid is present in all specimens of *Mioclaenus turgidus* in which M_3 was observed.

There is no certainty that this form represents the genus *Ellipsodon,* particularly since the premolars are not known. It is possible that a small species of *Mioclaenus* is represented.

The transverse diameter of the second lower molar is about 5 mm. The anteroposterior and transverse diameters of the third lower molar are 4.4 and 3.3 mm, respectively.

Ellipsodon? sp.

A lower jaw, U.S.N.M. no. 15781, is unusual in that the two teeth preserved, M_1 and M_2, have rather blunt cusps, a flattened talonid, and a relatively undepressed area between the three cusps of the moderately elevated trigonid. It resembles somewhat specimens from the Torrejon that have been referred to *Ellipsodon inaequidens* but with the paraconid more distinctly set off, although this cusp is subdued as are the other cusps of the teeth. This may represent an unusual condition in *E. shepherdi* but probably represents a distinct form whose affinities are uncertain.

Jepsenia, n. gen.

Type.—Jepsenia mantiensis, n. sp.

Generic characters.—Near *Litaletes,* but lingual portion of M^2 more expanded anteroposteriorly and hypocone weaker. Cusps of molars, particularly protoconule and metaconule, more nearly conical. Paraconule and metaconule better developed. Parastyle and mesostyle developed, more noticeably on M^2, although cingulum at anteroposterior angle of tooth not so extended. M^3 relatively smaller with less development of metacone and cingulum.

Jepsenia mantiensis, n. sp. Fig. 10

Type.—Portion of right maxilla with M^1 to M^3, U.S.N.M. no. 15747.

Horizon and locality.—Dragon Paleocene, Dragon Canyon, Emery County, Utah.

Specific characters.—Jepsenia mantiensis is slightly larger than *Litaletes disjunctus.*

Description.—Jepsenia mantiensis makes the closest approach to *Litaletes disjunctus* of the various hypsodont condylarths with which comparisons have been made. The upper molar series designated as the type is only slightly more robust than in the Montana form. M^1 has about the relative proportions of that in *L. disjunctus* and shows a distinct hypocone about as in that form. However, the lingual portion of M^2 is more expanded anteroposteriorly and the hypocone in this tooth is weaker and represented only by the abrupt termination lingually of the posterior cingulum. Also, the midportion of the posterior cingulum on both M^1 and M^2 is not deflected upward toward the root portion of the teeth so much as in *L. disjunctus.* The cusps in the upper molars have a more nearly conical appearance, especially the protoconule and metaconule. Moreover, the protoconule and metaconule are distinctly better developed. A parastyle and mesostyle are present, more noticeable in M^2, although the cingulum is not so extended at the anteroexternal portion of the molars. M^3 is relatively smaller than in *L. disjunctus* and the metacone, though distinct, is not so well developed, and the cingulum is less prominent and is discontinuous around the lingual and buccal surfaces of the tooth.

An M^2 with material numbered 15544 shows more acute anteroexternal and posteroexternal styles, no mesostyle, a lower protocone than in *L. disjunctus,* protoconule and metaconule relatively weak as in *L. disjunctus,* but the hypocone is much more lingual in position and is nearly matched by a protostyle on the anterolingual portion of the tooth, with the cingulum almost but not quite continuous around the inner margin of the protocone. M^1 in this material, though lacking a mesostyle, corresponds closely to that in the type of *Jepsenia mantiensis*. It is possible that the two molars, which were found close together, belong to the same individual and may represent a form distinct from the foregoing.

TABLE 5.—MEASUREMENTS (IN MILLIMETERS) OF UPPER TEETH OF *Jepsenia mantiensis*

	M^1	M^2	M^3
Anteroposterior diameter	4.5	4.4	3
Transverse diameter	5.4	6.4	4.6*

* Greatest transverse diameter.

Several isolated jaw fragments with single molars, one with M_2 and part of M_1, another with a well-worn M_2 and M_3, are presumed to represent *Jepsenia mantiensis*. The lower teeth in general show a distinct paraconid in a lingual position and a basined talonid with a strong hypoconid, a moderate entoconid, and a weak hypoconulid, which is the dorsal termination of a slight posterior cingulum rising from the posteroexternal portion of the tooth. The trigonid portion is not greatly different from that in *L. disjunctus*, although the entoconid on the heel is generally better developed and the small cuspule anterior to the entoconid is more distinct, however, in certain of the referred teeth there is little evidence of this accessory cusp.

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ORNITHOLOGY.—*Notes on some Asiatic owls of the genus* Otus, *with description of a new form.*[1]

H. Friedmann and H. G. Deignan, U. S. National Museum.

I

In the collections of Siamese birds in the U. S. National Museum are two specimens of *Otus* that are widely different from any other Asiatic form of the genus but are so closely and obviously related to the African *Otus senegalensis* that, in spite of the enormous geographical interval involved, we have no hesitancy in placing them in that species. In view of the difficulties inherent in such variable and poorly known birds as the Asiatic forms of *Otus*, we have borrowed extensively from the following institutions and private collectors, to whom our thanks are hereby expressed: The American Museum of Natural History, the Academy of Natural Sciences of Philadelphia, the Museum of Comparative Zoology, the Field Museum of Natural History, the Raffles Museum, and W. Koelz.

Otus senegalensis distans, subsp. nov.

Subspecific characters.—Very similar to (almost indistinguishable from) *Otus senegalensis hendersoni* of Angola but slightly washed with buffy on the upperparts, this wash especially noticeable on the pale bars of the outer rectrices and the primaries, and with the feathers of the lower sides and flanks less vermiculated, more whitish than in *O. s. hendersoni.*

Type.—U.S.N.M. no. 349931, adult female, collected at Sala Me Tha, Chiengmai Province, North Siam, February 20, 1936, by H. G. Deignan.

Description of type.—General color of upperparts dark brownish gray, *conspicuously mottled with black and white.* Feathers of crown largely black, with brownish-gray border, sometimes with a whitish spot. Feathers of nape gray or whitish, with an irregular black streak along apical third of shaft and narrow broken black bars, concealed portion washed with pale ferruginous. An ill-defined pale ferruginous collar across upper back, caused by color of concealed portion of feathers, which are otherwise white with a broad black streak along apical third of shaft and with black irregular crossbars. Feathers of back with a broad black shaft-streak, otherwise vermiculated with black and grayish white, sometimes washed with pale ferruginous. Rectrices light gray-brown with blackish-brown vermiculations and shaft-streaks. Outer webs of primaries broadly barred pale gray and brownish black; inner webs blackish brown with broad dull rufous bars, which become white toward edge approaching base of feather. Outer webs of secondaries broadly barred dull rufous and blackish brown; inner webs blackish brown with large white patches, not reaching shaft and inwardly tinged with pale ferruginous. The lesser upper wing coverts rufous with indistinct blackish bars, forming a *conspicuous reddish band the whole length of the forearm.* The median and greater upper wing-coverts like the remiges. Scapulars with the outer web wholly or largely pure white, giving the appearance of a broad

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[1] Published by permission of the Secretary, Smithsonian Institution. Received March 6, 1939.

white bar along sides of back, otherwise mottled gray and black, and with an interrupted black shaft-streak. Facial disk silver-gray, each feather with indistinct blackish crossbars. Disk edged at sides of neck by pale ferruginous feathers, which are subapically marked white and tipped black, forming a distinct black and ferruginous gorget, extending to nape, but interrupted on the breast. Feathers of breast and sides of neck whitish with broad dark gray tips, black shaft-streak and irregular black crossbars. Feathers of abdomen and flanks pure white or white faintly tinged ferruginous and with very broad black shaft-streaks and irregular narrow black bars. Under tail-coverts white with black shaft-streaks or immaculate. Tarsi feathered onto base of toes, white with scattered rufous macules. Bend of wing white. Under wing-coverts white with a few irregular black and ferruginous markings. In the dried skin the maxilla is horny-black; the mandible yellowish beneath, otherwise like the maxilla. Wing: 141.8; tail: 70.5; culmen from base: 19.5. First (outermost) primary equal to the eighth; second between fifth and sixth.

II

We have examined all the pertinent members of the genus known from Africa and eastern Asia and, in general, agree with the specific groupings of Stresemann (Mitt. Zool. Mus. Berlin **12** (1):191–195. 1925). We do not, however, accept the range of *malayanus,* as it has been understood in the past. *O. malayanus* is readily separable from *japonicus* by its much darker coloration (our 8 specimens are all in a red or brownish-red plumage) and by having the basal third of the tarsus naked; the third and fourth primaries are longest and the first (outermost) lies between the sixth and seventh or equals the seventh. *O. japonicus,* of which we have ample topotypical material, is much lighter, has both red and gray phases, and has the tarsus feathered to the base of the toes; the third and fourth primaries are longest, and the first lies between the sixth and the eighth.

A skin from Szechwan (April) and another from Yunnan (October) can not be matched in our series of *japonicus,* but they do agree in every particular with *malayanus* from the Malay Peninsula (where it is known only as a winter visitor). It seems probable that *malayanus* is a breeding form from southern China south to an unknown limit, occurring in winter as far as Malaya.

We have seen one specimen inseparable from Japanese *japonicus,* taken on the small island Koh Tao (Gulf of Siam) on the same day as a specimen of *malayanus.* This implies that *japonicus* may occur in winter anywhere within the range of *malayanus.* In view of this probability, Malayan specimens should be carefully compared with Japanese birds, especially the birds in gray phase recorded by Robinson.

We have also seen three winter specimens from northern and central Siam that are near to *japonicus* but differ in somewhat darker coloration, although they are still much lighter than *malayanus.*

Among the specimens sent us by Dr. Ernst Mayr are the birds from Burma and Assam, discussed by him in the Ibis for April, 1938, p. 313. With the more extensive comparative material before us, we have identified these birds quite differently.

"Otus scops modestus" from Dalu is not separable from specimens of *Otus sunia sunia* from Bengal.

The series of Assamese specimens that Dr. Mayr took to be typical *spilocephalus* is here tentatively referred to *O. scops sunia*, in the absence of definitely identified specimens of red phase *sunia*, but these four birds arouse the suspicion that they may be of an undescribed form. The bird from Dabahka, called *"Otus spilocephalus latouchi,"* is, in our opinion, true *Otus spilocephalus spilocephalus*, from which *latouchi* seems only doubtfully distinct.

In searching the literature with regard to the nomenclature of this group, we have discovered that *Pisorhina capensis grisea* Gunning and Roberts (Ann. Transvaal Mus. **3**:111. 1911. Bethulie, Orange Free State), is preoccupied by *Scops griseus* Jerdon (Madras Journ. Lit. Sci. **13**(2), no. 31:119. Dec. 31, 1844). We are not in position to pass on the validity of Gunning and Roberts' form, which, according to Chapin, "may perhaps prove separable," and therefore leave the renaming of it to some future student of the African scops owls.

Recently Junge (Treubia **16**(3):344. Aug., 1938) has considered *Otus umbra enganensis* Riley as a race of *O. sunia*. Previously Stresemann (Mitt. Zool. Mus. Berlin **12**:194. 1925) suggested with a question that *O. umbra* might be the same as *O. bakkamoena lempiji*. Chasen (*Handlist of Malaysian Birds*, p. 86, 1935) writes that *umbra* "can almost certainly be lumped with one of the other more widely spread Malaysian species, but as we have not seen either *umbra* or *enganensis* we can not attempt a wider nomenclature." We have examined the type specimens of *umbra* and of *enganensis* and find that they are not like any *O. s. malayanus* we have seen, and we consider them to form a specific group characterized by a massive bill and white bars on the chestnut flanks. In the type of *umbra* the first (outermost) primary is equal to the eighth, and the second is between the fifth and the sixth, whereas in *O. s. malayanus* the first is between the sixth and seventh, or equal to the seventh, the second between the fourth and the fifth. If Junge's Engano birds are really related to *sunia*, it may be that they represent an undescribed form. The type of *enganensis* has the primaries frayed, which prevents our giving its wing formula, and which also may account for the fact that Junge's bird had larger measurements than Riley gave for the type.

III

The form of *Otus bakkamoena* resident throughout Siam north of the province of Pattani (Malay Peninsula) has been considered identical with *lettia* of Nepal by all authors, except Chasen (*Handlist of Malaysian Birds*) who, without comment, calls the birds of Peninsular Siam *condorensis* of Kloss (Journ. Siam Soc. Nat. Hist. Suppl. **8**(2):81. 1930. [Pulau Condor, *ca.* 45 miles off the coast of Cochinchina]) and Riley (U. S. Nat. Mus. Bull. **172**) who attributes to the same race a specimen from East Siam and another from Southwest Siam (where it occurs side by side with "*lettia*").

O. condorensis was named on a series of only four specimens from an island possessing no other known endemic birds, the describer having at the time highly inadequate comparative material. The most northern specimen of "*lettia*" came from North Siam, other specimens from Raheng and Bangkok. Kloss was, moreover, misled by Stuart Baker into believing that *lettia* of Nepal and *lempiji* of Java are "practically the same in general tone of plumage"; accordingly, he diagnosed *condorensis* as being paler and larger than *lempiji*, paler and smaller than *lettia*.

The alleged size differences between *condorensis* and "*lettia*" are of the slightest according to Kloss's own measurements (the wing length of the former from 155 to 161 mm, of the latter from 158 to 167) and nonexistent when a good series of Siamese birds is examined. The alleged color differences do not appear at all in two birds from Cochinchina but do appear in odd individuals from Central and North Siam. There is some individual variation shown in the color of Siamese birds from any area, but all are considerably paler than *lempiji* and, to a less marked degree, paler than birds from Szechwan (and presumably Nepal also).

We have, unfortunately, not been able to examine *lettia* from Nepal. Birds from Szechwan have been called *glabripes* by authors, but they should at least show some approach to *lettia* for geographical reasons. They do, in fact, agree perfectly with a topotypical specimen of *glabripes* as well as with birds from Tongking. The further fact that we have found nothing in literature to indicate how *glabripes* may be distinguished from Nepalese *lettia* arouses some doubt as to the validity of the former, and we feel that the two races should be critically compared.

A series of 8 birds of both sexes (sexes alike in size) from Tongking and Szechwan have the wing length from 172 to 192 mm; a further series of 22 birds from Annam, Cochinchina, East Siam, Southeast Siam, Central Siam, West Siam, and North Siam have the wing length from 154 to 166 mm. Two birds from Southwest Siam measure 147 and 152 mm and seem to be approximating *lempiji*. Two specimens from Assam measure 161 and 167, thus falling into the size group of Indochinese birds.

The Fauna of British India, Birds, ed. 2 (4:427), embracing Assam and all Burma within the range of *lettia*, gives this race a wing length from 162 to 182 mm, and it seems reasonable to suppose that if only Nepalese birds had been measured even this slight overlap with Siamese birds would disappear. If *glabripes* prove indeed inseparable from *lettia*, the difference between Siamese birds and *lettia* will appear clearly from the measurements given above.

To the pale, short-winged birds of Annam, Cochinchina, Siam, ?Burma and ?Assam, we suggest that the name *condorensis* be applied.

Material examined:

Otus senegalensis	*griseus*	2	specimens
	graueri	1	“
	hendersoni	2	“
	senegalensis	2	“
	ugandae	2	“
	cæcus	4	“ (incl. type)
	distans	2	“
Otus cyprius		series	(A. M. N. H.)
Otus scops	*elegans*	“	“
	japonicus	23	specimens
	sunia	9	“
	rufipennis	1	“
	balli	1	“
	malayanus	8	“
	scops	11	“
	pulchellus	9	“
	menadensis	5	“
	steerei	1	“ (type)
Otus spilocephalus	*spilocephalus*	4	specimens
	latouchi	5	“
	siamensis	1	“ (paratype)
	vulpes	2	“
Otus rufescens	*malayensis*	2	specimens
	rufescens	1	“
Otus sagittatus		2	specimens
Otus umbra	*umbra*	1	specimen (type)
	enganensis	1	“ “
Otus cuyensis		2	specimens
Otus bakkamoena	*semitorques*	23	specimens
	pryeri	1	“
	glabripes	10	“
	bakkamoena	2	“
	condorensis	28	“
	lempiji	20	“
	mentawi	2	“
	fuliginosus	1	“
	whiteheadi	1	“
Otus capnodes		3	specimens
Otus rutilus		4	specimens

ENTOMOLOGY.—*The North American empoascan leafhoppers of the* radiata *group (Homoptera: Cicadellidae).*[1]

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The species of leafhoppers treated in this paper are characterized by a strongly produced crown, tending to be bluntly pointed, with the median length almost as long as, or in some cases longer than, the narrowest interocular space. The species of this group range in length from 2.75 to 3.75 mm. They are frequently well marked with distinctive color patterns and are usually easily distinguishable externally. However, from a study of the group in general, and from an examination of extensive western collections in particular, it appears obvious that several of the closely related species can be differentiated readily and accurately only by examination of the structures of the internal male genitalia.

Some of the species here discussed were originally included by DeLong[3] in the subgenus *Idona*, which he established with *minuenda* Ball[4] as the type, on the basis of the shape of the head. In addition to the type, he included in this subgenus *panda* DeLong, *junipera* DeLong, *elongata* DeLong, *rufa* DeLong, *tincta* DeLong, *morrisoni* Hartzell, *radiata* Gillette, and *mexicana* Gillette. Later, McAtee[5] pointed out reliable venational characters and raised *Idona*, with *minuenda* as the type, from subgeneric to generic rank, stating that "some of the other species certainly, and all of them probably, can well remain in the typical subgenus of *Empoasca* Walsh."

In view of the uncertain status of this group, a careful examination has been made of all available type material of the species involved. As a result, some synonymical changes are recorded and the group, of which *radiata* is a typical example, is redefined and considered as a part of the subgenus *Empoasca* Walsh. Only four of the original species are included in this *radiata* group, and, on the basis of the characters defining the group, *elongata*, *morrisoni*, and *panda* (because of their larger size and more rounded crown) are excluded and referred to the *fabae* group; *mexicana* Gillette, which will have as a

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[1] Paper no. 5120 of the U. S. Bureau of Entomology and Plant Quarantine. Received April 4, 1939.

[2] In the preparation of this paper the writer has had access to the U. S. National Museum collections and expresses her thanks to P. W. Oman, of the Division of Insect Identification, Bureau of Entomology and Plant Quarantine, for his cooperation and helpful criticism, and to Dr. R. H. Beamer, Dr. D. M. DeLong, and E. P. Van Duzee for loan of valuable material for comparison.

[3] U. S. Dept. Agr. Tech. Bull. **231**: 1–59. 1931.

[4] Proc. Biol. Soc. Washington **34**: 23–24. 1921.

[5] Proc. Zool. Soc. London, 1934, pt. 1: 107. 1934.

synonym *bitubera* DeLong, 1932,[6] is referred to the *alboneura* group; while *occidentalis*,[7] subsequently described by DeLong and Davidson, is placed in the *radiata* group. Another species, *ruficeps*, described in 1917 by Van Duzee from external characters only, apparently belongs to this group but was not included by DeLong in his revision of the genus.

This paper includes the description and illustrations of the internal male genital characters of *ruficeps*, together with those of five other species of the *radiata* group, four of them new to science. Three illustrations of each species are given, depicting both lateral and ventral views of the male genital capsule, and the ventral view of the sternal apodemes, and each drawing shows an enlargement of approximately 70 diameters.

The following key is presented as an aid in the separation of the species of the *radiata* group[8] now known to occur in North America.

KEY TO THE SPECIES OF THE RADIATA GROUP

A. Fore wing without definite gray or brown spots, and consequently without a mottled appearance.
  B. Posterior margin of seventh sternite of female with a median slightly produced lobe or tooth and a slight indentation on each side of it. General color olivaceous-green . . . . *junipera* DeLong
  BB. Posterior margin of seventh sternite of female not as above. General color yellowish, orange, or testaceous-green.
    C. Fore wing with orange or brownish stripes along the claval suture. Lateral processes, in ventral view, with apices curved laterad . . . . *radiata* Gillette
    CC. Fore wing without stripes along claval suture. Lateral processes, in ventral view, with apices not curved laterad.
      D. Fore wing tinged with testaceous. Lateral process, in ventral view, terminating in a small hook curved mesad . . . . *tincta* DeLong

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[6] Ohio Journ. Sci. **32**(4): 395. 1932.

[7] Ohio Journ. Sci. **35**(1): 32–33. 1935.

[8] After this manuscript was submitted for publication, Davidson and DeLong (Ohio Journ. Sci. **39**(2): 110–118. 1939) published descriptions of *Empoasca dorothyi*, *E. galluxa*, and *E. ancistra*, which apparently belong to the *radiata* group. Subsequent study of male paratypes of these species indicates that the first two bear a close resemblance, both externally and internally, to the species herein described as *E. crepidula*. The single specimen of each species available for examination may be differentiated by the relative length of the lateral process and the curvature of the apical portion of this process. In *dorothyi* and *galluxa*, the lateral process in ventral view is longer than in *crepidula*, but the apical portion is less curved mesad in *dorothyi* than in either *crepidula* or *galluxa*. It is possible that *crepidula* may prove to be an extreme variation of *dorothyi* and that a study of a longer series in each case, particularly of abundant material from northern Arizona, may show that *dorothyi*, *galluxa*, and *crepidula* are variants of a single species. The species described as *ancistra* is apparently close to what has been identified as *radiata* Gillette, but, since the male type of *radiata*, supposedly in the U. S. National Museum collection, can not be located, there is some question as to the proper identity of that species and decision in this matter must await further study.

DD. Fore wing tinged with smoky green or orange. Lateral process, in ventral view, without terminal hook.

E. Fore wing tinged with smoky green across center of clavus and apex, giving a banded appearance. Posterior margin of seventh sternite of female with a shallow median quadrangular emargination . . . . *occidentalis* DeLong and Davidson

EE. Fore wing tinged with orange, without banded appearance. Posterior margin of seventh sternite of female produced and rounded, without median quadrangular emargination.

F. Lateral process, in lateral view, relatively short and bluntly pointed . . . . *crepidula,* n. sp.

FF. Lateral process, in lateral view, long and sharply pointed . . . . *acuminata,* n. sp.

AA. Fore wing with definite gray or brown spots, giving a mottled appearance.

B. Head with a network of red pigmentation. Fore wing greenish white mottled with gray.

C. Lateral processes, in ventral view, crossed medially, their apices produced and curved inward . . . . *erythrocephala,* n. nom.

CC. Lateral processes, in ventral view, not crossed medially, their apices bluntly rounded and divergent . . . . *rubrarea,* n. sp.

BB. Head without a network of red pigmentation. Fore wing yellowish green mottled with orange, gray, or brown.

C. Lateral processes, in ventral view, crossed medially, their apices produced and overlapping . . . . . . *ruficeps* Van Duzee

CC. Lateral processes, in ventral view, not crossed medially.

D. Lateral process, in lateral view, with apex sharply pointed and curved dorsad . . . . *rubrarea* var. *indistincta,* n. var.

DD. Lateral process, in lateral view, with apex bluntly pointed and curved ventrad . . . . *delta,* n. sp.

Empoasca crepidula, n. sp. Fig. 1

Superficially resembling *occidentalis* but more yellowish and lacking banded appearance, and with a shorter lateral pygofer process and a small slipperlike spine. Length 3.75 mm.

External characters.—General color dull yellowish green tinged with orange. Crown irregularly marked with indistinct white areas. Pronotum with three large white spots along anterior margin. Scutellum with a median white stripe and a large white dot in center near apex, with a much smaller dot on each side. Fore wing subhyaline, with apex faintly fuscous. Seventh sternite of female with posterior margin slightly produced and rounded not notched medially.

Male internal structures.—Lateral process relatively short, extending only slightly beyond tip of style; in lateral view curving dorso-caudad, with apex appearing bluntly pointed; in ventral view broadly sinuate, with apical half curving gradually mesad and tapering to a point. Dorsal spine narrow at base and broadening into a small sharply pointed slipperlike shape with apex directed ventrocephalad. Sternal apodemes long and slender, bluntly rounded distally.

Described from one male and two females collected at Oak Creek Canyon, Ariz., August 9, 1932, by R. H. Beamer.

Holotype male and allotype and paratype females deposited in the Snow Entomological Collection, Lawrence, Kans.

Empoasca acuminata, n. sp. Fig. 2

A dull yellowish-green species, with long-pointed lateral process. Length 3.2 mm.

External characters.—General color dull yellowish green tinged with orange. Crown with median white line constricted at middle and with two oblique white dashes on each side near eye. Pronotum with four irregular white spots along anterior margin, median pair almost contiguous. Scutellum with median white area and three white spots near apex along incised line. Fore wing subhyaline, tinged with orange. Seventh sternite of female with posterior margin produced and rounded.

Male internal structures.—Lateral process long and pointed, slender at base and gradually broadening toward middle, with apical fourth tapering to long slender point directed caudad. Dorsal spine broad at base, with apical portion bluntly rounded and extending ventrad. Sternal apodemes large and saclike.

Holotype male, allotype female, and 12 male and 8 female paratypes from Nogales, Ariz., October 20, 1937, P. W. Oman, collector.

Type, U. S. N. M. no. 53285. Four paratypes deposited in collection of the entomological laboratory of the U. S. Bureau of Entomology and Plant Quarantine, Arlington Experiment Farm, Arlington, Va.

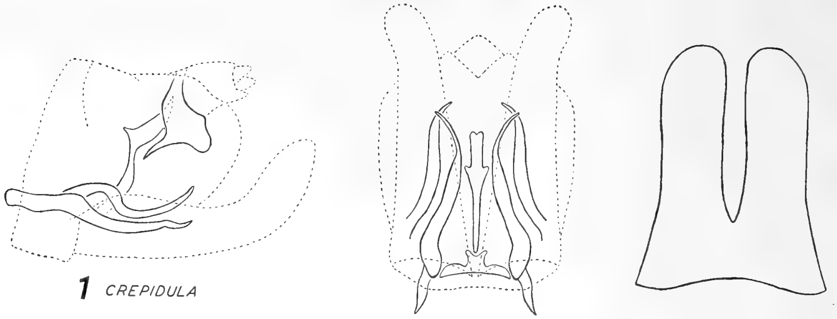
Empoasca erythrocephala, new name Fig. 3

Empoasca rufa DeLong (*nec* Melichar, Homop.-Fauna v. Ceylon: 212. 1903), U. S. Dept. Agr. Tech. Bull. 231: 53–54. 1931.

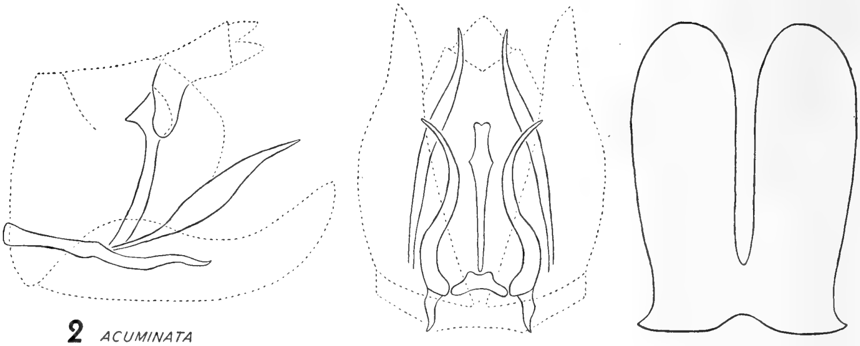
From specimens collected at Pasadena, Calif., DeLong, in 1931, described as *Empoasca rufa* DeLong (*nec* Melichar) a small (3.2 mm) white species with reddish mottling on the head and with crown bluntly pointed. Melichar in 1903, from external characters only, had previously described as *E. rufa*, a scarlet-red, foreign species, 4 1/5 mm in length, illustrating the head, fore wing, and hind wing. From a study of the illustrations and the description of Melichar's species, and from a comparison with specimens in the U. S. National Museum collection, which appear to be that species, *rufa* Melichar is considered representative of an oriental group of *Empoasca* having no close relation with the *radiata* group. DeLong's species is therefore given the new name *erythrocephala* and is reillustrated, for the purpose of comparison with other closely related species, from specimens collected by R. H. Beamer at Claremont, Calif. The types of *rufa* DeLong are in the collection of E. D. Ball.

Empoasca rubrarea, n. sp. Fig. 4

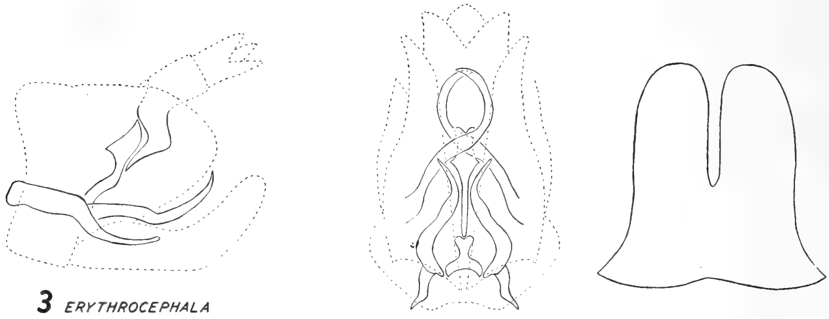
Superficially resembling *erythrocephala*, but with a shorter dorsal spine and the lateral processes in ventral view not crossed in the middle. Length 2.75–3 mm.



1 CREPIDULA



2 ACUMINATA



3 ERYTHROCEPHALA

Figs. 1–3.—Lateral and ventral views of male genital capsule and ventral view of sternal apodemes of (1) *Empoasca crepidula,* n. sp., (2) *E. acuminata,* n. sp., and (3) *E. erythrocephala,* new name. × ca. 70.

External characters.—General color pale greenish white, with the network of bright red pigmentation on upper portion of face and crown less heavily outlined than in *erythrocephala;* irregularly marked with red on pronotum and scutellum and on base and costal margin of fore wing. Fore wing also flecked with small gray spots, the larger spot on middle of clavus along commissural line much darker and more distinct than in *erythrocephala;* apex fuscous, with pale nervures. Seventh sternite of female slightly produced and rounded posteriorly.

Male internal structures.—Lateral process in lateral view relatively stout, curving dorso-caudad, with dorsal margin slightly concave at distal portion, terminating in a sharply pointed apex directed dorsad; in ventral view curving mesad, then caudad, with distal portion slightly enlarged and bluntly rounded. Dorsal spine rather indistinct, slightly broader at base, deeply concave on cephalic margin and curved to sharply pointed apex directed ventrocephalad. Aedeagus broad distally. Sternal apodemes medium sized, bluntly rounded distally.

Described from a series of 53 males and 93 females collected by R. H. Beamer, July 24, 1935, in Santa Barbara County Park, 13 miles east of Nipomo, Calif., labeled "Nipomo, Cal." There are also at hand collections by R. H. Beamer consisting of one male from Claremont, Calif., July 29, 1935, and 14 males and 20 females from Topango Canyon, Calif., August 5, 1938.

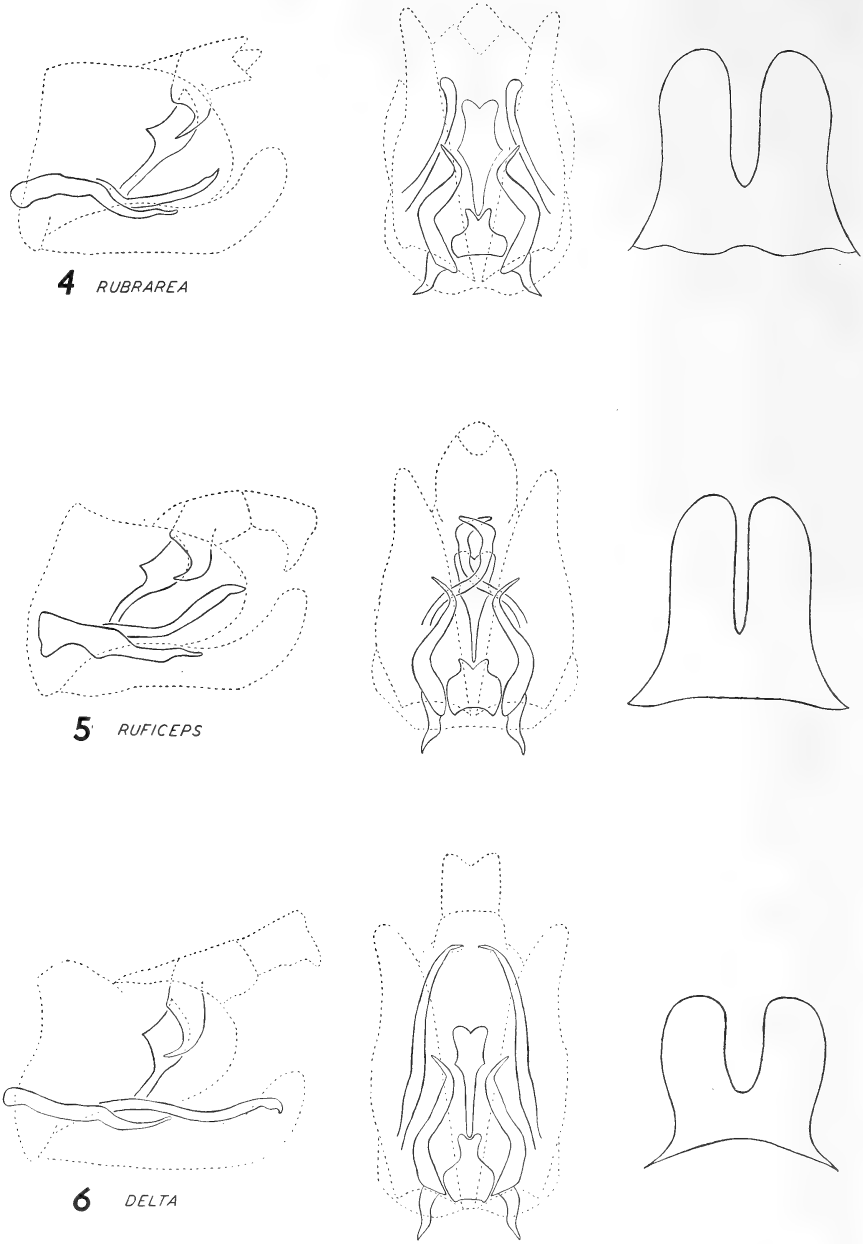
Holotype male, allotype female, and 25 male and 45 female paratypes deposited in the Snow Entomological Collection, Lawrence, Kans.; 15 male and 15 female paratypes deposited in the U. S. National Museum (no. 53286); 12 male and 32 female paratypes deposited in the collection of the entomological laboratory of the Bureau of Entomology and Plant Quarantine at the Arlington Experiment Farm, Arlington, Va.

Empoasca rubrarea var. **indistincta,** n. var.

Agreeing with *rubrarea* in general form and with identical internal genital structures, but more yellowish in color and lacking the network of bright red pigmentation on head and other red markings. Length 2.75–3 mm.

External characters.—General color yellowish green. Crown tinged with orange, with four small white spots along anterior margin, a larger spot on each side near eye, and a white median area constricted in middle, sometimes forming two distinctly separated spots. Pronotum and scutellum tinged with orange, the former with three larger white spots along anterior margin and the latter with a median white spot near anterior margin and three smaller white spots along the incised line. Fore wing mottled with orange and more sparsely flecked with gray than *rubrarea,* but with a similar, distinct, fuscous spot on middle of clavus, and apex fuscous with pale nervures. Seventh sternite of female like that of *rubrarea.*

Holotype male, allotype female, and 8 male and 8 female paratypes from Monterey, Calif., July 22, 1935, collected by R. H. Beamer. Other paratypes as follows: One male from Cajon, Calif., June 6, 1935, and 1 male from Mint Canyon, Calif., June 7, 1935, collected by P. W. Oman; 1 male and 2 females, Beaumont, Calif., July 26, 1933, 2 males and 2 females, San Gabriel Canyon, Calif., July 27, 1935, 4 males and 8 females, Monrovia, Calif., July 27, 1935, and 4 males, San Diego, Calif., August 7, 1935, all collected by R. H. Beamer; 6 males and 6 females collected by Jack Beamer, Monterey, Calif., July 22, 1935.



Figs. 4–6.—Lateral and ventral views of male genital capsule and ventral view of sternal apodemes of (4) *Empoasca rubrarea*, n. sp., (5) *E. ruficeps* Van Duzee, and (6) *E. delta*, n. sp. × ca. 70.

Holotype male, allotype female, and 15 male and 14 female paratypes deposited in the Snow Collection, Lawrence, Kans.; 6 male and 6 female paratypes deposited in the U. S. National Museum (no. 53287); and 6 male and 6 female paratypes in the collection of the entomological laboratory of the Bureau of Entomology and Plant Quarantine, Arlington Experiment Farm, Arlington, Va.

Empoasca ruficeps Van Duzee Fig. 5

Empoasca ruficeps Van Duzee, Proc. California Acad. Sci. **7** (ser. 4): 304–305. 1917.

External characters.—Small, yellowish green, mottled with brown, with pronotum and scutellum marked with sanguineous-brown, and apex of fore wing deeply infuscated, with strong pale nervures. Length 3.5 mm.

Male internal structures.—Lateral process in lateral view curving dorsocaudad, basal half with sides almost parallel margined, apical half slightly broader, terminating in a blunt point directed caudad; in ventral view the lateral processes are long, curving first mesad and crossing near middle, extending slightly laterad, then caudad, broadening distally, then tapering to bluntly pointed, overlapping apices directed laterad. Dorsal spine broad at base, deeply concave on cephalic margin, with sharply pointed apex directed cephalad. Aedeagus narrow at base, enlarged distally. Sternal apodemes medium sized, bluntly rounded distally.

Van Duzee described *ruficeps* from 30 specimens collected at Los Altos, Calif., July 26, 1916, on pitcher-sage (*Sphacele colycina*), and at Westpoint, Mount Tamalpais, 1,300 feet elevation, August 16, 1916. The drawings (Fig. 5) were made after examining male and female paratypes received from Van Duzee, 1 female collected at Mount Diablo, Calif., June 21, 1935, by Oman and compared by him with the type, and 5 males and 5 females collected at Lockwood, Calif., July 25, 1935, by R. H. Beamer.

Empoasca delta, n. sp. Fig. 6

Resembling *ruficeps* somewhat in general appearance, but smaller, with pronotum and scutellum yellowish green and less marked with sanguineous-brown, and apex of fore wing less deeply infuscated. Genital characters distinct. Length 2.5–2.75 mm.

External characters.—Crown tinged with orange, with a pale spot on each side near eye and a pale median area, sometimes constricted in middle, forming a pale spot at apex and one at middle of posterior margin. Pronotum yellowish green, with three paler areas near anterior margin, the middle one outlined by a dark line on each side and the lateral areas each surrounded by several dark-brown dots. Scutellum yellowish green, with a median white area and a transverse row of three pale points just below the incised line, the apex terminating in a conspicuously dark-brown point. Fore wing subhyaline, yellowish green, mottled with brown, sometimes with orange, with a small rufous-brown spot near tip of clavus; apex fuscous, with pale nervures. Posterior margin of seventh sternite of female rather strongly produced from prominent lateral angles.

Male internal structures.—Lateral process long, curved, relatively stout, with sides parallel to near apex; in lateral view distal portion slightly enlarged and terminating in a short fingerlike process curved downward; in ventral view distal portion angularly bent on inner margin and curved on outer margin to sharply pointed apex directed mesad. Dorsal spine stout, tapering to a sharp point, curved cephalad. Aedeagus broad distally. Sternal apodemes medium sized, bluntly rounded distally, with apices more widely separated than in *ruficeps*.

Holotype male, allotype female, and numerous paratypes of both sexes from Delta, Calif., June 28, 1935, P. W. Oman, collector. Types, U.S.N.M. no. 53288. Twelve paratypes deposited in collection of the entomological laboratory of the Bureau of Entomology and Plant Quarantine, Arlington Experiment Farm, Arlington, Va.

Empoasca mexicana Gillette

Empoasca mexicana Gillette, Proc. U. S. Nat. Mus. **20**(1138): 737–738. 1898.
Empoasca bitubera DeLong, Ohio Journ. Sci. **32**(4): 395. 1932. (New synonymy.)

As previously mentioned, *mexicana*, because of the more rounded crown and the pale nervures of the fore wing, belongs in the *alboneura* group, but the writer treats it here in order to establish the synonymy indicated.

The original description of *mexicana* by Gillette was based on 5 females collected near Veracruz, Mexico, type no. 3430, U. S. National Museum. Later DeLong[9] redescribed specimens "as apparently this species" and illustrated the male genitalia from a series in the U. S. National Museum collection consisting of 5 females and 3 males collected at Marfa, Tex., June 5, 1908, by Mitchell and Cushman, stating that Gillette's type could not be located in the National Museum. From an examination of this series now extant, consisting of 1 male (dissected), 3 females, and 2 specimens with abdomens missing, the external markings and internal structures of the male were found to be identical with those described and figured later by DeLong for *bitubera*. *Empoasca bitubera* is therefore placed as a synonym of *E. mexicana* Gillette.

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[9] U. S. Dept. Agr. Tech. Bull. **231**: 56–57. 1931.

MAMMALOGY.—*A new badger from Sonora.*[1]

E. A. GOLDMAN, U. S. Bureau of Biological Survey.

The badgers of the widely dispersed species, *Taxidea taxus*, are divisible into several closely allied geographic races. One of these, hitherto unrecognized, from near the southern known limit of the species along the eastern side of the Gulf of California is described as follows:

Taxidea taxus sonoriensis, subsp. nov.

Type.—From Camoa, Rio Mayo (about 15 miles above Navojoa), Sonora, Mexico. No. 96211, ♂ young adult (frontoparietal sutures fused), U. S. National Museum (Biological Survey collection); collected by E. A. Goldman, November 29, 1898. Original number 13263.

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[1] Received June 1, 1939.

Distribution.—Lowland plains region of southern Sonora; limits of range undetermined.

General characters.—A rather small, dark-colored subspecies with conspicuously blackish chin; white median dorsal stripe ending near shoulders, or extending as a very narrow, more or less interrupted line to lower part of back, but not normally reaching over rump; nasals narrowing abruptly posteriorly at point of contact between maxillae and frontals. Closely allied to *Taxidea taxus berlandieri* of western Texas, but general color slightly darker, more extensively mixed with black; chin usually distinctly blacker; nasals narrowing more abruptly at point of contact between maxillae and frontals. Very similar to *Taxidea taxus infusca* of southern Lower California, but white median dorsal stripe less continuous posteriorly (extending over rump in *infusca*); chin usually distinctly blacker; cranium flatter and differing in detail.

Color.—*Type:* Facial area, including eyes, and forehead (except median line), and patches on sides of head in front of ears black as usual in the species; irregular white markings under and behind eyes confluent with white of under parts; white median line extending from middle of face to near shoulders; general dorsal area and sides of body a coarse mixture of buff, black, and white, the individual hairs pinkish buff at base, becoming black subterminally and white at tip; general abdominal area light buff thinly streaked with black, becoming pure white along a narrow median line; under side of neck pure white; chin and spot at base of median tuft of vibrissae on throat blackish; ears blackish, edged with white; fore and hind limbs black; upper side of tail similar to back, but basal color of hairs more cinnamon-buff, under side of tail more predominantly cinnamon-buff.

Skull.—Very similar in size and general form to that of *berlandieri*, but nasals narrowing more abruptly at point of contact between maxillae and frontals (in *berlandieri* the nasals are more evenly V-shaped, tapering gradually to a point posteriorly); mastoids more rounded and fully inflated, dentition about the same. Compared with that of *infusca* the skull is somewhat broader and flatter, the brain case less highly arched, basioccipital broader; nasals broader, less evenly tapering posteriorly (differing to about the same extent as from *berlandieri*); auditory bullae less bulging below level of basioccipital, dentition similar.

Measurements.—*Type:* Total length, 662 mm; tail vertebrae, 122; hind foot, 100. An adult female topotype: 625; 110; 107. *Skull* (type and an adult female topotype, respectively): Condylobasal length, 114.7, 113; zygomatic breadth, 69.8, 70.9; breadth of braincase (across mastoid processes), 70.7, 69.5; height of braincase (over auditory bullae), 48.5, 48.4; interorbital breadth, 24.2, 25.2; postorbital constriction, 27.4, 28.6; palatal constriction, 14.1, 13.5; maxillary tooth row (alveoli), 35.8, 38.5; crown length (outer side) of upper carnassial, 11.4, 12.5; crown width of upper carnassial, 8.8, 9.8.

Remarks.—*Taxidea taxus sonoriensis* appears to be most closely allied to *T. t. berlandieri,* with which it doubtless intergrades on the north. One of the most distinctive cranial details noted is the abruptly narrowing outline of the nasals, which is quite uniform in the series of topotypes.

Specimens examined.—Total number, 6, all from Sonora, as follows: Camoa (type locality), 5; Costa Rica Ranch (about 40 miles southwest of Hermosillo), 1 (skull only).

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1138TH MEETING

The 1138th meeting was held in the Cosmos Club Auditorium, Saturday, October 8, 1938, President **Heck** presiding.

Program: **Sterling B. Hendricks**, U. S. Bureau of Chemistry and Soils: *Random structures and water sorption in clays.*—The crystal structures of a number of minerals related to the micas were described, and models illustrating some of their structures were exhibited. Three general problems were then discussed: (1) Why is kaolin, $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$, polymorphic and why is aluminum only slightly replaceable by iron or magnesium in the kaolins? (2) What is the structure of the hydrates of the clay minerals? (3) Why do some minerals related to talc show diffuse reflections and what is the connection between this property and random factors present in the structures? (*Author's abstract.*)

R. W. **Goranson**: *On the electrical properties of multilayers.*—Experiments were described which demonstrated that the electrical properties of multilayers of stearic acid, as formed by the Langmuir-Blodgett method, were caused by the adsorption of metallic ions from the substrate. It was shown that these ions were present in the multilayer as a volume distribution. Evidence was presented as to the existence of a marked influence of the speed of building the multilayers on the electrical properties. While adsorbed positive charges were always present, at speeds in excess of a certain value, negative frictional charges also developed. The frictional charges were caused by the relative motion of film and aqueous substances. (*Author's abstract.*)

The first paper was discussed by Messrs. **Roller**, **Brickwedde**, and **Teller**; the second one by Messrs. **Mohler**, **Brickwedde**, and **Gibson**.

1139TH MEETING

The 1139th meeting was held in the Cosmos Club Auditorium, Saturday, October 22, 1938, President **Heck** presiding.

Program: N. **Smith**, National Bureau of Standards: *Regular characteristics of the ionosphere during half a sunspot cycle.*—The sun is the principal source of the energy that produces the ionization in the earth's upper atmosphere. The increase in solar activity from the sunspot minimum in 1933 to 1938 resulted in large increases in this ionization. During this period the maximum ionization density of the E layer, at about 130 km in height, increased by a ratio of 1.55 to 1, and the maximum ionization density of the F_2 layer, at about 300 to 400 km in height, increased by a ratio of 4 to 1. This means an increase in the solar radiation responsible for the E layer by a ratio of about 2.4 to 1 and for the F_2 layer by a ratio of about 16 to 1. The ionization of the E layer has followed fairly well in phase with the sunspot cycle, whereas the ionization of the F_2 layer showed somewhat of a lag.

Superimposed on this long-period increase of ionization were the more or less regular diurnal and seasonal variations. The diurnal and seasonal variations of E layer ionization for the most part accord quite well with the simple theory of ionization by ultraviolet radiation from the sun, but the variations in F_2 layer ionization show that other factors must be taken into consideration. (*Author's abstract.*)

S. S. KIRBY, National Bureau of Standards: *The sporadic-E layer of the ionosphere.*—The sporadic-E layer is a term used to designate a layer of the ionosphere which reflects radio waves from a height about that of the normal-E layer but at sporadic intervals of time and frequently at scattered geographical locations although occasionally the effect is general over wide areas. The reflections occur at much higher frequencies than from the normal-E layer and sometimes at higher frequencies than from the F_2 layer. As additional contrasts to the normal-E and F_2 layers, the sporadic-E has no smooth diurnal and seasonal variations but occurs both day and night principally in summer, does not exhibit marked critical frequency effects, and is often semitransparent over wide frequency ranges. These effects have been indicated by vertical incidence ionosphere measurements.

The sporadic-E layer is responsible for moderately long distance propagation of ultra-high frequencies at sporadic intervals of time and usually over scattered geographical areas, but occasionally over wide areas. These results have been indicated chiefly by amateur transmissions at 56 Mc/s over distances from several hundred to 2,000 or more kilometers.

Both the vertical-incidence ionosphere measurements and the long-distance transmissions convey the impression that sporadic-E layer is formed at sporadic time intervals in clouds which are usually very much limited in geographical distribution but sometimes are widespread.

Data have been compared and no definite relations have been found between the occurrence of sporadic-E layer and thunderstorms, ionosphere storms, or fadeouts at Washington.

The sporadic-E layer does not appear to be an intense ionization produced directly by sporadic solar activity. A more reasonable explanation is that the effect is caused by reflections from the sharp boundary of a layer of moderate ionization density and that the direct cause of the sharp boundary is largely terrestrial. Since the normal-E layer has a fairly sharp boundary the change in distribution of ions would not have to be very great. (*Author's abstract.*)

The papers were discussed by Messrs. BRICKWEDDE, MCNISH, MARIS, HUMPHREYS, MOHLER, BROMBACHER, MAXWELL, SEATON, and VESTINE.

1140TH MEETING

The 1140th meeting was held in the Cosmos Club Auditorium, Saturday, November 5, 1938, President HECK presiding.

Program: WALTER RAMBERG: *Flexural vibrations of rotating propeller blades.*—Flexural vibrations of propeller blades are believed to be an important cause of the propeller failures that have occurred from time to time under flight conditions. A previous study of nonrotating propeller blades which had been set to vibrate flexurally had shown that the measured natural frequencies and stress distributions agreed with those given by considering the propeller blade as a straight slender beam of variable section. A report of this work was presented before the Society on April 13, 1935.

The present paper extends the theoretical portion of this work to include the effect of rotation at service speeds. The integral equation was derived for a propeller blade that vibrates flexurally with a symmetrical mode. This equation was solved for two aluminum alloy propeller blades of typical design vibrating with the fundamental mode and with the second harmonic mode. The two extreme conditions of rigid clamping at the hub and of zero clamping at the hub were considered.

Rotation was found to shift the maximum stress per unit tip deflection toward the hub and it raised the value of this maximum up to 10 percent. Rotation caused an increase in natural frequency that could be predicted closely by substituting the deflection curve for no rotation in Lord Rayleigh's expression for the natural frequency of an elastic system. The model rules due to Theodorsen were discussed which show that the stress distribution and the frequency for flexural vibrations in a given blade may be determined directly provided that this blade is affine in dimensions to a type blade for which solutions are already available. The need for experimental work was emphasized to check the assumptions of the theory and to determine which natural modes of the propeller-crankshaft system are most dangerous in leading to fatigue failure. (*Author's abstract.*)

L. B. Tuckerman: *Heterostatic loading and critical astatic loads.*—Southwell has shown how, in some cases, it is possible to compute the critical astatic load, i.e., the elastic buckling load, of a structure from measurements of its heterostatic deflections at lower loads. The history of the theory of heterostatic loading and Southwell's method is briefly reviewed. Westergaard's general theory is then applied to the problem. It is shown that Southwell's method and Lundquist's modification of it are theoretically accurate for results of measurements which are proportional to the value of any one astatic parameter. These measurements need not be deflection measurements but may be strain measurements or, theoretically, measurements of any effect linearly dependent upon the deformation. Further, the parameter need not be the parameter corresponding to the lowest critical load but theoretically may correspond to any higher critical load.

Southwell's method is thus useful in cases where measurements within the elastic range can be made to depend primarily upon the change of a single astatic parameter. If the measurements are affected appreciably by changes in other parameters, the critical load computed by Southwell's method or Lundquist's modification may be considerably in error. A combined numerical and graphical method of computation is outlined which by successive approximations gives more accurate results in such cases. Finally experimental results are given in which the second and third critical loads of a "round end" Euler column are computed from strain gage measurements taken at loads below the first critical load. (*Author's abstract.*)

The first paper was discussed by Messrs. Tuckerman and Nelson; the second one by Messrs. Teller, Deming, Ramberg, and Nelson.

1141st MEETING

The 1141st meeting of the Society was held in the Cosmos Club Auditorium, Saturday, November 19, 1938, President Heck presiding.

Program: J. W. Beams, University of Virginia: *Some applications of high rotational speeds.*—A few high-speed vacuum-type air-driven centrifuges are described and their operating characteristics given. Their applications to such problems as the separation of isotopes, purification of material, determination of molecular and particle weights and sizes, are discussed. A brief description is also given of the new magnetically-supported electrically-driven vacuum-type centrifuge. Like the air-driven centrifuge, the maximum rotational speed of this electrically-driven magnetically-supported centrifuge is limited only by the bursting strength of the centrifuge. Six-inch rotors have been spun at speeds above 1,000 rps. The speed does not vary by more than 1 rps. for periods of six hours, and the temperature of the rotor remains very constant. The technique of spinning long tubes about a vertical axis in a vacuum to very high speeds is briefly described, and their use as centrifuges for gases and liquids is outlined. The material to be centrifuged enters the spinning tube at one end and is collected in light and heavy samples at the other. (*Author's abstract.*)

An informal communication on "Natural Diffraction Spectra in Agates" was presented by J. W. McBURNEY.

1142D MEETING

The 1142d meeting, constituting the 68th annual meeting, was held in the Cosmos Club Auditorium, Saturday, December 3, 1938, President HECK presiding.

The treasurer reported that the income from dues and from interest on investments was $1,366.19 and that the expenditures, other than investments, were $1,313.83, leaving a net surplus of $52.36 on ordinary expenses. The ordinary expenditures were at the rate of $4.27 per member. The treasurer reported that, with the approval of the General Committee, he had sold certain securities of the Society, reinvested a portion of the proceeds in other securities, and is conducting negotiations for the investment of the balance in other securities.

The secretaries' joint report showed an active membership as of December 1, 1938, of 308, of whom the following were elected during the year: RAY L. DRISCOLL, LESTER R. FRANKEL, CHRISTOS HARMANTAS, ENOCH KARRER, R. B. KENNARD, PAUL S. ROLLER, OTIS W. SWAINSON, E. H. VESTINE, DAVID WERTMAN, and GLADYS WHITE. The following were elected in 1937 and qualified in 1938: WESTLEY F. CURTIS, THEODORE B. GODFREY, H. F. KAISER, FOREST R. MOULTON, FRANCIS W. STRUTHERS, ROLLA H. TAYLOR, and MERLE A. TUVE.

The annual report of the General Committee described the outstanding items of business that had come before the General Committee during the year as follows: (a) Changes in the bylaws of the General Committee relative to the conduct of elections; (b) necessity of curtailment of ordinary expenses due to decreased income from investments; and (c) elimination of an item of expense for subscription to the JOURNAL OF THE WASHINGTON ACADEMY OF SCIENCES for members of the Society who are not members of the Academy. These items were discussed by Messrs. DRYDEN, HUMPHREYS, SEEGER, and HOWE.

Changes in the bylaws relative to the conduct of elections were adopted as recommended by the General Committee and were made retroactive.

W. D. LAMBERT made some comments and recommendations regarding the preparation and mailing of ballots and instructions to voters. This matter was discussed by Messrs. TUCKERMAN, WERTHEIMER, MOHLER, McNISH, SILSBEE, and BLAKE.

The following officers were declared elected for the year 1939: *President*, F. G. BRICKWEDDE; *Vice-Presidents*, R. E. GIBSON and H. E. McCOMB; *Recording Secretary*, R. J. SEEGER; *Treasurer*, H. F. STIMSON; and *Members-at-Large of General Committee*, WALTER RAMBERG and A. G. McNISH.

Program: HERBERT G. DORSEY: *Sono radio buoys for hydrographic surveying.*—These buoys were developed by the U. S. Coast and Geodetic Survey to serve as inexpensive hydrophone stations in radio acoustic ranging.

Each sono radio buoy consists of one or more hollow steel drums to contain the electrical apparatus and furnish buoyancy to float the superstructure and counterweight.

In one of these drums there is an audio amplifier, designed primarily for frequencies below 200 cycles, a keying tube and a crystal controlled radio transmitter. A total of five or six 2-volt tubes is used, all biased to cut off so that no B battery current is required, except about two milliamperes screen grid current, when no signal is received. The filaments are kept heated continuously by dry batteries. Bomb signals are received from the water by an electromagnetic hydrophone, suspended below the sono radio buoy, the impulse of which is amplified by the audio amplifier, actuating the keying tube which furnishes screen grid current to the transmitting tube, sending a short radio signal from the antenna supported on the superstructure.

The time elapsed between firing the bomb by the surveying ship and the return of the radio dash is measured to 0.01 second on the ship's recording chronograph and by such returns from two or more sono radio buoys placed in known locations the ship's position can be located with far greater accuracy than by any method other than visual fixes.

These sono radio buoys have now been successfully used by the U. S. Coast and Geodetic Survey for the past three seasons and their use has been adopted by the U. S. Naval Hydrographic Office during the past year. (*Author's abstract.*)

In discussing this paper Mr. P. A. SMITH presented a slide showing some of the detailed hydrographic work that has been done recently by this method off the eastern shore of the United States.

H. E. McCOMB, *Recording Secretary*

1143D MEETING

The 1143d meeting was held in the Cosmos Club Auditorium, Saturday, December 17, 1938, President BRICKWEDDE presiding.

Program: E. A. JOHNSON: *Measurement of small magnetic moments.*—In order to measure the magnetic polarization of weakly magnetized sediments, an electromagnetic method of measurement has been developed which is very sensitive. The magnet to be measured is rotated inside of a fixed coil at ten cycles per second and the voltage induced in the coil is measured by an alternating-current amplifier and synchronous commutator. The limiting sensitivity is computed from the calculated signal voltage and the thermal agitation in the input circuit. The limiting sensitivity can be obtained in practice. Moments of 3×10^{-7} CGS unit can be detected and with specimens 1.5 cm on a side 8×10^{-8} CGS unit/cc can be detected. The method has allowed the study of the weak magnetic polarization in unmetamorphosed sediments and has led to interesting results in regard to the direction of the compass in prehistoric times. The direction of polarization can be determined to within 1° with the apparatus. (*Author's abstract.*)

A. G. McNISH: *The residual magnetization of rocks.*—To extend records of changes in the earth's magnetic field over a greater length of time than is covered by historic records, measurements have been conducted on the residual magnetization of sedimentary rocks. Unmetamorphosed sediments are believed to have acquired their magnetization through alignment of their magnetic constituents under the directive influence of the earth's magnetic field at the time of their formation. Measurements on the deposits of varved Pleistocene clays left at the recession of the last ice-sheet from New England have revealed distinct differences in direction of their residual magnetization suggestive that for a 200-year period studied the average direction of the earth's field was 30° west of its present direction in the same region. Variations occurring during this period indicate that secular change was in progress at the time with rates of change comparable with those observed today. Measurements on sediments from the bottom of the ocean also reveal secular change, although the measurements on these sediments may not be directly related to present values of declination. (*Author's abstract.*)

The first paper was discussed by Messrs. F. L Mohler, H. E. McComb, and W. Ramberg; the second one by Messrs. R. B. Kennard, N. H. Heck, F. G. Brickwedde, W. J. Humphreys, A. S. Hawksworth, and J. Pawling.

1144th MEETING

The 1144th meeting was held in the Cosmos Club Auditorium, Saturday, January 14, 1939, President Brickwedde presiding.

The Retiring President, N. H. Heck, gave an address entitled *From the center of the earth to the sun.* This address was published in this Journal **29**: 189–218. 1939.

1145th MEETING

The 1145th meeting was held in the Cosmos Club Auditorium, Saturday, January 28, 1939, President Brickwedde presiding.

Program: E. O. Hulburt: *The brightness of the twilight sky.*—The sunlight illumination of the twilight sky was investigated for the purpose of determining the density and temperature of the atmosphere to as great an altitude as possible. As the sun sets, the earth's shadow above the observer moves upward and the region of the atmosphere illuminated by the direct rays of the sun moves to high levels. A reversed sequence of events occurs before dawn. Measurements were made during clear weather of the brightness of the zenith sky for about an hour after sunset and an hour before sunrise. From the measurements, combined with the known intensity of sunlight and the law of scattering of light by air, the density (or pressure) and the temperature of the atmosphere were determined. Corrections were made for secondary scattering which were obtained from measurements of the brightness of the sunset or sunrise glow of the twilight sky near the west or east horizon.

The temperature came out to be between 205° and 235° K from 12 km to about 60 km. Thus, the temperature of the upper air was cold and was roughly constant with altitude. From the temperature the pressure was determined. No important changes were noted with the season from October, 1937, to April, 1938. For altitudes above about 60 km the method fails, since at greater heights the light of the twilight sky is very weak and the corrections due to secondary scattering are relatively large. These results refer only to the atmosphere during conditions of twilight at Washington, D. C., latitude 40° north. In general, one would expect that the upper air grow warmer during the day and cooler at night. However, the day and night change between 20 and 60 km may not be very great, and might be supposed to increase with increasing altitude. (*Author's abstract.*)

R. E. Gibson: *Effect of pressure and temperature on the transmission of light by certain solutions.*—The solutions of aromatic amines in nitrobenzene are highly colored even though the pure components are practically colorless. This paper presented the results of a study of the light transmitted at different pressures and temperatures by some of these solutions, especially those of aniline in nitrobenzene which under ordinary conditions have a deep orange color. It was found that rise of pressure at constant temperature decreased the amount of light transmitted by the solutions much more strongly than could be accounted for by the compressibility of liquids. As the light of shorter wave lengths (green and yellow) was absorbed more strongly at the higher pressures, the visible effect was an apparent change in the color of the solution. It was also found that the increase of temperature at constant pressure had no detectable effect on the transmission of light by these solutions, even when the volume change produced by a given change of temperature, e.g., 85 to 25°, was approximately the same as that produced by a rise of pressure, viz., 1 to 1,000 atm.

The absence of a temperature coefficient together with other thermodynamic properties of the solutions made it highly improbable that the color of these solutions was due to the formation of addition compounds, and, to account for the absorption of light by the solutions and its change with increase of pressure, the hypothesis was advanced that the amount of light of the longer wave lengths absorbed by the solutions was determined by the frequency and violence of collisions between the nitro and amino groups on the unlike molecules. Additional evidence in favor of this hypothesis was presented.

Taking into account the known behavior of the oxygen atoms in the nitro groups as electron-attracting groups and the known tendency of the $-NR_3$ group to act as an electron-repelling group, a mechanism was suggested whereby at the moment of collision an aromatic amine might lower the energy of the excited state of the nitro-group in nitrobenzene. As confirmatory evidence the behavior of solutions of p-nitro-acetanilide in nitrobenzene which are practically colorless was cited.

Studies of the effect of pressure and temperature on the light transmitted by these solutions suggest that in these solutions we have examples of the limiting case of compound formation in solution and of the production of profound changes in the light-absorption of molecules by intermolecular disturbances.

The first paper was discussed by Messrs. J. PAWLING, F. L. MOHLER, L. B. TUCKERMAN, P. A. SMITH, W. G. BROMBACHER, and W. L. HUMPHREYS; the second one by Messrs. P. A. ROLLER, J. A. DUERKSON, W. J. HUMPHREYS, and J. BECK, JR.

Mr. J. PAWLING presented an informal communication consisting of a typical photograph of two sunspots.

1146TH MEETING

The 1146th meeting was held in the Cosmos Club Auditorium, Saturday, February 11, 1939, President BRICKWEDDE presiding.

Program: H. F. STIMSON: *The measurement of the specific heat and the latent heat of water from 0° to 100°C.*—Precise determinations were made of the specific heat of water from 0°C to 100°C. These are of value in determinations where water is used as a standard of heat capacity. The latent heat of vaporization was determined at 15 selected temperatures from 100°C down to 0.15°C.

The theory of the method was outlined and the apparatus described. Some of the precautions to attain accuracy were enumerated and the formulation of the results described. The agreement of the formulation with the experimental results for the specific heat showed a precision of better than one part in 10,000 but it was pointed out that the accuracy is not necessarily that high. (*Author's abstract.*)

E. TELLER: *Report on the theoretical conference on low temperature phenomena.*—This year's Theoretical Conference centered around low temperature physics. One of the main questions was connected with the magnetic method for production of extremely low temperatures. To reach low temperatures it is necessary to find some modes of motion that will persist to low temperatures. Such motion is that of the magnetic dipole of electrons and the question discussed at the conference concerned the coupling of magnetic dipoles with other degrees of freedom. Another group of questions was related to the zero-point energy of the lightest atoms. This zero-point energy is responsible for the different behaviors of solid or liquid hydrogen and deuterium. The remarkable properties of the low temperature modification of liquid helium are, however, the most striking illustrations of quantum effect. For this liquid helium the designation "quantum helium" has been used, since it is zero-point energy rather than temperature motion that keeps it from solidifying. Liquid helium also may serve as a model for the droplet theory of the atomic nucleus. (*Author's abstract.*)

The first of these papers was discussed by Messrs. F. D. ROSSINI, F. C. KRACEK, W. F. WHITE, W. J. HUMPHREYS, L. B. TUCKERMAN, and J. PAWLING; the second one by Messrs. A. S. HAWKSWORTH, L. R. MAXWELL, F. D. ROSSINI, and F. G. BRICKWEDDE.

1147TH MEETING

The 1147th meeting was held in the Cosmos Club Auditorium, Saturday, February 25, 1939, Vice-President GIBSON presiding.

Program: J. PAWLING: *The formation of a revised second Bordeaux catalog.*

H. C. HAYES: *Sap flow and pressure in birch trees.*

Sap flow resembles respiration rather than circulation. The tree starts taking in sap under certain stimulating conditions that are not fully understood and continues until boiler pressures of considerable magnitude are established. After maintaining these high pressures for a period of several hours the tree starts expelling sap and continues until the pressure approaches zero and occasionally becomes less than atmospheric pressure. Maximum pressures slightly in excess of 200 centimeters of mercury above and minimum pressures as low as 6 centimeters of mercury below atmospheric pressure have been recorded.

Sap pressure appears to be independent of the size or height of the tree. It tends to rise and fall with the temperature, but no relation between temperature and pressure has been established or even approximated. Moreover, a comparison of many simultaneous temperature and pressure records leads to the belief that factors other than temperature must operate to account for some of the rapid pressure fluctuations where changes as great as 2 or 3 cm of mercury may occur within a minute of time during which there is no measurable change of temperature. Such pressure influencing factors, if they exist, can be traced to the sun for the reason that these small, erratic and relatively rapid pressure fluctuations do not occur during the night.

Pressure changes occur practically simultaneously in all trees in the same locality. This statement apparently holds even for the small rapid pressure fluctuations which are usually present during the hours of sunshine. This fact proves that the stimulus causing the change of sap pressure in a tree comes from without the tree.

The resistance to sap flow through the tree varies between wide limits becoming surprisingly small during the periods when the pressure is high and active to much greater values when the pressure is low and inactive.

The seat of the sap pressure lies in the new cell growth about the tips of the tiny root hairs. Both pressure and pressure changes appear to depend on the vital activity of these cells because their experimentally determined values can not be accounted for by osmosis and/or capillary action. These cells apparently have the ability to store energy which, under some external stimulus not fully understood, is expended in forcing sap into the trees against pressures approaching 40 pounds per square inch and in maintaining such pressures over periods of several hours. The termination of such pressure periods appears to be definite and practically simultaneous in all trees of the locality as though it were caused by cessation of the pressure-inducing stimulus which then permits the sap to pass outward to the soil through the action of gravity. There is also the possibility that the outward flow of sap is due in part to reversal of activity and not to inactivity of the root cells.

The first of these papers was discussed by Messrs. H. F. STIMSON, A. S. HAWKSWORTH, P. A. SMITH, W. J. HUMPHREYS, R. J. SEEGER, and C. BARAFF; the second one by Messrs. P. S. ROLLER and P. A. SMITH.

1148TH MEETING

The 1148th meeting was held in the Cosmos Club Auditorium, Saturday, March 11, 1939, President BRICKWEDDE presiding.

Program: RICHARD B. ROBERTS, Department of Terrestrial Magnetism of the Carnegie Institution: *The splitting of uranium and thorium nuclei by neutrons.*—Several years ago Fermi and collaborators observed that artificial radioactivity is induced when uranium is bombarded by neutrons. Recently Hahn and Strassman have shown by chemical methods that among the radioactive elements produced are barium, cerium, and lanthanum. This observation was explained by Meitner and Frisch as a fission on the uranium nucleus into two roughly equal parts with approximately 200 million electron-volts of energy released in the process. This theory was soon confirmed by observing the ionization produced by these heavy and highly energetic particles. Neutrons were also found to be emitted in this fission process and these neutrons might conceivably lead to an exothermic chain-reaction. However, it appears very probable that separated isotopes of uranium in large quantities would be necessary to sustain such a chain-reaction. (*Author's abstract.*)

MICHAEL GOLDBERG: *Linkage mechanisms in three dimensions.*—A closed chain of n hinged links in three dimensions (that is, a linkage in which the hinges are not all parallel) has, in general, n-6 degrees of freedom. When n is less than seven, the linkage is generally rigid; a movable chain is said to be "paradoxical." Models of the known paradoxical linkages of less than seven links were exhibited and discussed. These included the plane and spherical linkages, the Bricard 6-bar linkage, which is the basis of the deformable octahedron, the Bennett 4-bar linkage, a new 5-bar linkage and two new 6-bar linkages discovered by the speaker, plane and line symmetric 6-bar linkages, a special 6-bar linkage of 90° twisted links, and several classes of linkages employing plane links. (*Author's abstract.*)

The first paper was discussed by Messrs. E. TELLER, W. G. BROMBACHER, F. C. KRACEK, C. BARAFF, and L. R. MAXWELL.

1149TH MEETING

The 1149th meeting was held jointly with the Washington Academy of Sciences in the Cosmos Club Auditorium, March 16, 1939, with President CHAMBERS of the Academy presiding.

Professor ENRICO FERMI, Department of Physics, Columbia University, spoke on *The mesotron.* The lecture was discussed by members of the Academy and of the Philosophical Society.

1150TH MEETING

The 1150th meeting was held in the Cosmos Club Auditorium, Saturday, March 25, 1939, President BRICKWEDDE presiding.

The Ninth Joseph Henry Lecture entitled *Recent developments of cosmic-ray investigation* was delivered by Dr. THOMAS H. JOHNSTON, Assistant Director of the Bartol Foundation of the Franklin Institute. This lecture, which was discussed by Mr. C. BARAFF, has been published in this JOURNAL **29**: 233–256. 1939.

1151ST MEETING

The 1151st meeting was held in the Cosmos Club Auditorium, Saturday, April 8, 1939, President BRICKWEDDE presiding.

Program: CHARLES K. GREEN, Coast and Geodetic Survey: *Submarine topography in the pilot house.*—Until the advent of echo sounding the average mariner gave but little thought to the configuration of the ocean bottom while cruising in deep water. As long as his course was free from dangers it mattered little whether the vessel at the moment was passing over a submarine knoll or a steep sided canyon. He could not utilize the charted depths for fixing his position without stopping the ship and measuring the depth with a wire—a time-consuming procedure resorted to in exceptional cases only. For ordinary navigation in deep water it was not practicable to use this method.

Today, however, it is possible to obtain a continuous profile of the bottom with the vessel underway. This means that deep-water bottom relief has become important to the man in the Pilot House, since it is available for practical use in guiding his ship. Bottom features in deep water areas are not readily discernible on the conventional chart, on which soundings only are shown. A new method of charting was therefore needed.

The first nautical chart to show detailed bottom relief by depth contours has just been issued by the Director of the Coast and Geodetic Survey. This chart, 5101A, covers the area off the coast of Southern California and the 50-fathom depth contours printed in blue bring into prominence the many submarine "landmarks" useful to mariners in fixing position by echo sounding.

By this method of charting, full use can be made of the survey data, whereas on the conventional type chart of this area, only two percent of the soundings could be used without impairing legibility. (*Author's abstract.*)

O. W. SWAINSON: *Problems of the modern hydrographer.*—To develop radio acoustic ranging to its present state of reliability where the position of soundings taken in hydrographic surveying out of sight of land and for distances up to 200 miles can be obtained, enabling the accurate charting of submarine canyons and mountains, it was necessary to solve many problems. Some of those described were the development of safe and special bombs to be fired at depths up to 6,000 feet using a single electrical conductor; the determination of the path of the refracted sound wave in sea water; and the overcoming of the difficulty of reflection from submarine canyon walls and mountain sides. A formula was described for obtaining the distance of the bomb from the hydroplane using the approach to parallelism of travel time curves with distances over 30 miles. (*Author's abstract.*)

The first paper was discussed by Messrs. J. PAWLING and M. GOLDBERG; the second one by Messrs. G. T. RUDE, W. BOWIE, P. A. SMITH, and A. S. HAWKSWORTH.

1152D MEETING

The 1152d meeting was held in the Cosmos Club Auditorium, Saturday, April 22, 1939, President BRICKWEDDE presiding.

Program: E. L. KLEIN, Naval Research Laboratory: *Radiation pressure and its measurement.*—The paradoxical history of radiation pressure is recalled. It is pointed out that, whether regarded on the basis of the wave theory or quantum theory, radiant energy possesses momentum. With this momentum is always associated radiation pressure. The smallness of radiation pressure is illustrated by calculating the tremendous power that a searchlight or loud speaker requires in order that the radiation pressure in the beam of light or sound might support a 2-ounce hat. This negligible effect on earth is contrasted with the incredible magnitudes of radiation pressures dealt with in astrophysics.

Devices for measuring radiation pressure of light and of sound are depicted. Apparatus utilizing this effect in standardizing subaqueous acoustics are discussed. It is shown how the radiation pressure developed by a sound generator may be evaluated by two distinct radiometric instruments under identical conditions. Secondary standard microphones are calibrated by the aid of these devices. (*Author's abstract.*)

L. B. TUCKERMAN: *Mathematics as she are taught.*—Very many otherwise competent and well-trained engineers are either afraid of mathematics or scornful of any engineering use of anything but the most elementary mathematics. They can hardly be blamed for this attitude when they find that the so-called mathematics, which they have been taught, repeatedly gives them wrong answers. Some engineering textbooks in wide current use even encourage them in this attitude by sneering at sound mathematical treatment and by treating some mathematical problems in ways which are inadequate, misleading, or even wholly wrong.

Examination of textbooks of algebra, calculus, and function theory in wide current use today shows that these inadequate, misleading, and wrong treatments in engineering textbooks are to be ascribed partly, at least, to equally inadequate, misleading, and wrong treatment of fundamental principles with which many mathematical textbooks, which are supposed to teach mathematics, are filled. It is no wonder that many students give mathematics up as useless and hopeless, convinced that they never can understand it.

These statements are substantiated by many excerpts (shown as lantern slides) from textbooks in wide current use, containing, not a few minor slips, but many different inadequate, misleading, and wrong statements about fundamentals.

Fortunately some textbooks are not so bad as those from which these excerpts are taken and some teachers are careful to correct the faults of the texts. Nevertheless there is urgent need for drastic reform of the textbooks and the teaching of elementary mathematics in our schools. (*Author's abstract.*)

The first paper was discussed by Messrs. H. F. STIMSON, P. A. SMITH, A. S. HAWKSWORTH, and H. L. CURTIS; the second by Messrs. A. WERTHEIMER, M. GOLDBERG, and T. DANTZIG.

1153D MEETING

The 1153d meeting was held in the Cosmos Club Auditorium, Saturday, May 6, 1939, President BRICKWEDDE presiding.

Program: H. L. CURTIS, C. MOON, M. SPARKS, F. WENNER, J. L. THOMAS, I. L. COOTER, F. R. KOTTER: *Absolute measurements of electrical resistance.*—The resistance of a conductor in absolute ohms is the ratio of the potential difference between its terminals, in absolute volts, to the current, in absolute amperes, which is flowing through the conductor. However, the determination of the resistance in absolute ohms has usually been made by methods which do not require the measurement, in absolute units, either of the potential difference or of the current. By the methods used at the National Bureau of Standards a comparison is made of the potential difference between the terminals of a resistor carrying a current and the electromotive force which is induced in an inductor when this same current is changing in a definite manner. Then the absolute value of the resistance is obtained from the value of the inductance, which may be computed from its dimensions, and from a time interval which is determined from the manner in which the current changes. At the National Bureau of Standards two different methods have been carried to completion, in one of which a self inductance was employed and in the other a mutual inductance.

I. Self-Inductance Method. In the self-inductance method an alternating current bridge was used for comparing the self inductance with a capacitance and two resistances. The capacitance was then measured in a direct-current bridge in which the capacitor was charged and discharged a known number of times per second. The capacitance could be eliminated between the equations which connect the constants of these two bridges so that the inductance was determined in international henrys when the resistances of the two bridges were in international ohms. The value of the inductance in absolute henrys was computed from the mechanical dimensions of the inductor and the permeability of the space which surrounded it. The ratio of these two values of the inductance gave the correction factor for converting the value of a resistance in international ohms to its value in absolute ohms.

The self inductor used in the determinations outlined above was a single-layer solenoid. The solenoid was wound on a pyrex glass form, over a meter in length, in which a screw thread was cut and lapped on the outer surface. Two problems were involved, one to have the pitch uniform, the other to have the diameter uniform. The method of lapping gave a pitch which was so uniform that methods of measurement were not available for showing that there were any variations. The maximum variation in diameter was about one micron. In order to have the wire sufficiently uniform in diameter and free from kinks, it was drawn directly onto the cylinder. When a flat oilstone was passed lightly along the length of the finished solenoid, a spot was polished on each of the wires; the depth of a spot being less than a micron in every case. If there had been a variation in the diameter of the wire as much as 0.1 micron it could readily have been detected by observing these spots.

II. Mutual-Inductance Method. The method of measurements involved: (1) cyclic reversals of the current in the primary winding of the mutual inductor without opening the primary circuit; (2) cyclic reversals of the connections to the secondary winding without opening the secondary circuit; (3) the maintenance of a practically constant current in that part of the primary circuit containing the resistance which was being measured; (4) the maintenance of a practically zero current in the secondary circuit when adjustments were such that the rectified value of the induced electromotive force was equal to the potential drop across the resistor; (5) when adjustments are properly made, $R=4nM$, where R is the measured resistance, n is the frequency of the primary current cycle and M is the mutual inductance. When M is expressed as the product of cm, μ_0 and 10^{-9}, and n is the number of cycles per second, R is in absolute ohms.

The mutual inductor was a modification of the Campbell type. The primary was a solenoid wound on a porcelain form and constructed by a somewhat similar method to that used for the solenoid in the self inductance method. However, the winding was not continuous but had two gaps which were symmetrical with respect to the center. This type of winding gave, outside the primary, a region in which the magnetic field was practically zero. The second winding was placed in this region. The secondary was wound in a groove made by cementing together three plate-glass rings, all having the same inside diameter but the two outer ones having a larger outside diameter than the inner ring.

III. Results. The ratio of the absolute ohm to the international ohm by the two methods is in very satisfactory agreement. The average value by the self inductance method for 104 measurements taken during the past year can be stated as

1 NBS international ohm = 1.000 484 absolute ohms.

The value so far obtained by the mutual inductance method is

1 NBS international ohm = 1.000 485 absolute ohms.

(*Authors' abstract.*)

The above program was presented as four papers. The theory of the self-inductance method was presented by H. L. Curtis, the experimental procedure and results of that method by C. Moon, the mutual inductance method by F. Wenner, and the mutual inductor by J. L. Thomas. These papers were discussed by Messrs. P. A. Smith, L. B. Tuckerman, C. Snow, A. S. Hawksworth, E. Buckingham, and E. C. Crittenden.

1154TH MEETING

The 1154th meeting was held in the Cosmos Club Auditorium, Saturday, May 20, 1939, President Brickwedde presiding.

Program: A. Bramley, Bureau of Chemistry and Soils: *A thermal method for the separation of gases and isotopes.*—Methods for separating gases by thermal diffusion [Chapman and Dootson, Phil. Mag. **33,** 248 (1917)] have been improved by making the process accumulative [Clusius and Dickel, Naturwiss. **33,** 546 (1938); Brower and Bramley, Phys. Rev. **55,** 590 (1939);

Bramley and Brower, American Chemical Society Abstracts, Baltimore Meeting (1939)]. Our glass apparatus consists of two concentric cylinders, the inner one heated, the outer one cooled. Measurements were taken on a 50–50 mixture of CH_4 and NH_3 at 20 cm pressure. The cylinders were 100 cm long; the inner cylinder had a diameter of 1 cm. As the diameter of the outer cylinder was changed from 1.3 cm to 5.4 cm, the separation went through a broad maximum. As the optimum diameter of 2.5 cm the mixture showed a 27 percent enrichment of NH_3 at the bottom. With this apparatus, diameter of outer tube 2.5 cm and inner 1 cm, measurements were made on the effect of time, temperature, and pressure. At a pressure of 20 cm and average temperature of 150°C. the separation reached 90 percent of its final value in 15 minutes. At this same pressure, the separation increased as the average temperature of the gas increased up to 170°C. With a fixed power input, the separation increased as the pressure decreased from 60 to 20 cm; below that it decreased again. Measurements have been made on separating the chlorine isotopes of HCl. (*Author's abstract.*)

Brian O'Brien, Institute of Optics of Rochester University: *The problems of solar variability and new methods of attack.*—There are many indications of variability of the sun. The number and distribution of sun spots exhibiting clearly an eleven-year periodicity, changes in form of the solar corona, fluctuations in the earth's magnetic field, and changes in the ionosphere all give evidence of periodic variation of solar origin. The recent and excellent correlation between radio fade-outs and chromosphere flares is further evidence of solar variation reflected in terrestrial phenomena.

Perhaps the most direct method of attack on the problem of solar variation is the systematic measurement of radiation received from the sun. This offers no great problems so far as the determination of radiation received at the earth's surface, but to remove terrestrial effects from such measurements it is necessary to determine, at the same time, the transmission coefficients of the earth's atmosphere. The difficulties of determining these precisely are very considerable, but this problem has been attacked with much success by the Smithsonian Institution over a period of years. As a result the total radiation emitted by the sun, the form of its spectral energy curve, and the spectral transmission coefficients of the terrestrial atmosphere under clear air conditions are known with high accuracy.

The fluctuations observed in total radiation as received from the sun outside the earth's atmosphere are small, but there is reason to believe that these may be of much importance. Any improvements in the accuracy of determination of the atmospheric transmission coefficients (the principal source of uncertainties) are thus very desirable. While measurements are less complete there is good evidence that fluctuations in solar radiation are much greater in the near ultraviolet than are those at longer wave lengths.

In view of the above we have attacked the problem by measurement in the ultraviolet and at high levels in the earth's atmosphere. This is being done in two ways. By the use of sounding balloons, photoelectric keyed radio-telemetering instruments are carried to altitudes of the order of 20 km, above which level the uncertainties remaining in atmospheric transmission are very small. While excellent in principle, this method imposes very severe operating conditions for a precision instrument. The second method, which is applied independently, consists in precise measurement at two spectral regions (one in the ultraviolet and one in the infrared both removed from regions of strong absorption) of the solar radiation simultaneously at the earth's surface and at altitudes attainable by an airplane. By this means the uncertainties in transmission of the lower atmosphere due to dust, water droplets and other contaminations are eliminated.

Although both methods are being tested experimentally, the instrumental precision is not yet as great as desired, and development work is being continued. Details of this will be discussed. (*Author's abstract.*)

The first of these papers was discussed by Messrs. R. E. Gibson, A. K. Brewer, L. R. Maxwell, and L. B. Tuckerman; the second by Messrs. F. L. Mohler, L. R. Maxwell, T. A. Smith, L. B. Tuckerman, C. G. Abbot, and H. L. Curtis.

Raymond J. Seeger, *Recording Secretary*

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JOURNAL
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VOL. 29 AUGUST 15, 1939 No. 8

BIOLOGY.—*The measure of population divergence and multiplicity of characters.*[1] ISAAC GINSBURG, U. S. Bureau of Fisheries. (Communicated by WALDO L. SCHMITT.)

In two previous papers (1937 and 1938) I discussed the problem of the species and its subdivisions and concluded that the lines drawn between these taxonomic categories must of necessity be arbitrary. In the later paper I employed a method for determining the precise divergence between natural populations, based on the character showing the greatest divergence (designated by Davenport, 1898, as the principal character, and the same term used in this paper), for the purpose of drawing pertinent arbitrary lines between those taxonomic categories. The question of multiplicity of characters was mentioned only in a passing manner. This paper takes up this question in some detail.

The determination of divergence may be considered with reference to time and to extent. Each one of these two factors may be considered further with reference to a single character and to a number of characters.

Time is, of course, an important element in divergence. With reference to time, changes that result in the differentiation and isolation of populations from preexisting populations, as manifested by any one character, may be roughly divided into two categories: rapid and slow. The former class may be called explosive evolutionary changes. Changes sometimes designated as mutations are of the explosive kind. (Geneticists have appropriated the use of the word mutation to express the idea of a change in the gene of any kind or degree. I use the word in the original sense, that is, to signify a perceptible change that is sudden, stable, heritable, and of appreciable magnitude, no matter what its immediate cause may be. We need two separate words to express these two ideas.) While probably not infrequent, it is apparently not the usual *modus operandi* of nature in evolution. The biological evidence adduced up to now makes it apparent that evolution, the differentiation of new populations from

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[1] Received February 2, 1939.

preexisting ones, usually takes place by slow changes. It may be assumed that, in general, each succeeding generation—or at least some individuals thereof—differs, in any one given character, very slightly from the preceding one. The difference between any two successive generations, considered in their entirety as separate populations, is usually so slight as to be imperceptible by our rather crude methods of observation and measurement. But the minute differences are cumulative, and when any two widely separated generations are compared, they may be detected by statistical methods. (It may be possible to test now the truth of this assumption. Possibly some museum has an adequate sample, collected a hundred or so years ago, of a population of plants or animals that reproduce annually and that have a short span of life, say, one or two years. Such a sample, when compared with a sample of the same population as it exists today, would represent an interval of 50 or more generations. With respect to evolution, biologists are usually in the habit of thinking in terms of geological time; but hardly anything is known now in regard to the time factor in evolution. Possibly in some cases an interval of even 50 or 100 generations may produce cumulatively, under natural or wild conditions—leaving out of consideration laboratory or domesticated conditions—a very small but statistically measurable difference. Crampton (1916, pp. 57, 120; 1932, pp. 78, 95) presents evidence to show that some populations of terrestrial gastropods of the genus *Partula* have undergone average morphological changes, sometimes to a considerable extent, during an interval of a little over half a century, as well as changes in their geographic distribution. Although no detailed observations appear to be extant on the span of life, the age at maturity, and the time frequency of reproduction in *Partula*, it seems safe to assume that a year represents the time interval of one generation and quite probably more than one.)

Though time no doubt plays an important role in evolution, it is hardly of practical importance in discussions of the species problem. For one thing it can not now be determined with anything approaching precision, or, more generally, it can not be determined at all. It is also reasonable to assume that there is no sharp line of demarcation between the above two classes of change with respect to time, and that one gradually merges into the other. We recognize only extreme examples of the explosive kind that happen to come under our observation and designate them as mutations. Even in populations undergoing comparatively slow changes there are apparently all degrees of differences in tempo. In general, it is obvious that some populations, especially those belonging to certain genera, are now in a state of flux, actively changing and proliferating (the taxonomically so-called "difficult" genera are of this kind), while others show no perceptible change during long intervals of time, hardly differing even from their remote, fossil ancestors. Consequently, even if it were possible to use the time factor in determining divergence, we would have to draw arbitrary lines there also, the same as in the determination of the extent of divergence. Furthermore, the time factor, taken by itself, can not be used as a universal criterion in determining divergence. It is obvious that this factor depends on the span of life, age at maturity, fecundity, and length of the reproductive period of the particular population. Primarily it depends on the interval of time occupied by a generation, which, from this standpoint, may be taken to be its actively reproductive period.

Chiefly from a practical standpoint, therefore, the extent of divergence is the important thing to consider. If pairs of closely related, natural populations diverge to approximately the same extent, at least by the principal character, they are to be regarded as of the same taxonomic rank no matter whether they diverged by explosive or by slow evolutionary changes of different degrees.

In determining the extent of divergence the usual existence of a multiplicity of characters introduces a disturbing element. If closely related diverging populations differed by only one character, the extent of their divergence could be expressed readily and almost completely by the measure employed in my paper referred to (1938), or by some similar measure. But diverging populations usually differ in more than one character. The diagram I presented (1937, p. 187), to illustrate the gradual series obtained when the divergences of the chief distinguishing character or the principal character of a number of pairs of populations are arranged in order, may also be used (omitting the horizontal lines) as a general graphic illustration of the divergences of several characters between a single pair of populations. That is, when two closely related diverging populations are carefully studied, we find that usually they differ in several characters showing different degrees of divergence. The difficulty introduced by the usual existence of several diverging characters as between any given pair of populations was obviated by me (1938) by using the principal character as the basis of determining and measuring the extent of divergence. This method is seemingly incomplete. How are we to express the degree of divergence of two closely related populations by taking into consideration other characters in which they diverge in addition to the principal character? What weight, if any, are these other characters to be given in measuring divergence? An altogether satisfactory answer to this question can not be given at present; but apparently not much weight should be placed on the other characters.

The problem of the measure of divergence as related to a multiplicity of characters may also be considered with reference to time and extent. With respect to time it is reasonable to assume that when a pair of populations diverge in more than one character, the several characters, in general, change about simultaneously, although this is probably not always and not altogether so. Consequently, it seems probable that the time element is usually of not much importance in determining the hypothetical sum total of divergence of all the characters. As far as the time factor is concerned, the principal character apparently forms an adequate basis for a measure of divergence. In any case, the time factor is not definitely determinable, and we are forced to leave it out of consideration in practice. While the time factor is of much theoretical interest, its consideration at present must be almost altogether of a speculative nature. For practical work in taxonomy we must rely on the extent of divergence. This is the factor of much practical importance in taxonomy, and it may be determined with some measure of precision.

(Geneticists may be dissatisfied with some of the above statements. For instance, some would probably object to the idea of changes being cumulative in an accretive sense, with reference to degrees of magnitude in the development of a given character; and would restrict the idea to a statistical sense, that is, the gradually cumulative addition to the population of individuals showing a given change or changes. With respect to any one presumably single factor character, they probably would express the idea of a cumulative change in a population in their language, in terms of a change, for some largely unknown causes, in the frequency ratios of alternative alleles. With respect to several characters, or any one presumably multiple factor character, they may want to express the idea as the statistical accumulation of mutant genes in the population. However, I am speaking here from the point of view of the taxonomist. The chief cause of difference in the points of view of taxonomists and geneticists is that the latter deal mainly with a particular and comparatively restricted kind of differences, qualitative differences; whereas taxonomists deal with all kinds of populations, and the great majority of closely related populations differ quantitatively, not in the absolute, but in having different frequency distributions that very often overlap, even in those populations that are generally regarded by taxonomists as of the rank of species. Because of the difference, by and large, in the material with which they work, they even think in different terms. Geneticists usually think of characters as of something being present or absent, or as of something that may manifest one form of two or more alternative and more or less discrete forms. Taxonomists, on the other hand, in consequence of the things with which they are more familiar, generally think of characters as being variables that vary in a gradual manner about a more or less central mode, and in case of continuous variables, in virtually infinitesimal gradations. Another consequence is that in considering divergence between closely related populations, geneticists appear to think of and often lay stress on its being discrete or discontinuous, whereas taxonomists think in terms of degrees of magnitude that are virtually infinitesimally graded.

If current ideas regarding multiple factors and manifold effects of single genes are accepted as a working hypothesis, the proposition of a cumulative change in degrees of magnitude of a gradually variable quantitative character is not excluded, on the assumption that the change in the visible character is due to changes in a number of genes. Therefore, no matter how the propositions are stated, they refer to the same conclusion, that is, the usual way in which perceptible evolutionary changes in populations are brought about in nature is by the slow accumulation of minute differences.

The business of the taxonomist is to distinguish populations—species, subspecies, and races—by their visible morphological characters. The determination of their genetic constitution is a coordinate but, in practice, a separate problem. While a good beginning has been made toward an understanding of the operation of the genetic factors in heredity, it is only a beginning, and it may be expected that current hypotheses will be modified with increased knowledge. What the taxonomist is doing is to study the end products of the very complex interaction of genetic factors. A proper synthesis of the two closely allied branches of biology, genetics and taxonomy, is sorely needed. Perhaps, in the present state of knowledge, the time is not yet ripe for such a constructive synthesis. Meanwhile, I am here speaking the language of the taxonomist. The statements made above flow as a a plausible consequence of his experience. They also do not seem to be in conflict with the known facts so far uncovered in genetic studies.)

The *extent* of divergence of a multiplicity of diverging characters may be considered by referring to some hypothetical populations. Let us assume a pair of closely related populations, *alpha* and *beta*, that differ by two characters, *A* (Fig. 1) and *B* (Fig. 2). The divergence of character *A* is such that no intergrades exist; that is, the extent of divergence is 100 percent, every individual may be definitely referred to one or the other population on the basis of this character; while character *B* shows a very high degree of intergradation. Let us assume further another pair of population, *gamma* and *delta*, that also differ by two characters, *C* (Fig. 3) and *D* (Fig. 4), both characters showing a moderate degree of intergradation. Character *D*, as indicated in the figure, is assumed to show a slightly higher degree of intergradation than *C*, and *C* is, therefore, the principal character as between these two hypothetical populations. In this hypothetical case a number of individuals are not definitely referable to either population on the basis of any one character. When both characters are considered a number of such intergrades will likely be placed with a satisfactory measure of assurance by one of the characters falling near the mode or even near the outer extreme end of the distribution of its population; but a residue of the individuals will likely have both characters intergrading.

Judged by criteria now in practical use by biologists in distinguishing populations, it is evident that the first pair of the foregoing two hypothetical pairs of populations shows a relatively greater extent of divergence than the second pair, because every individual, without exception, can be definitely referred to its proper population. The relative degree of divergence between the first pair of populations, as compared with that between the second pair, may be indicated by some measure expressing the extent of divergence of the principal character in the two pairs, characters A and C, respectively. But how are we going to combine the divergence of the two characters in each pair of populations in order to compare the relative divergence of the two pairs? Apparently a combination that will include the full measure of divergence of each character separately will likely show a higher relative divergence of the second pair of populations, a misleading result. If we are to include the lesser diverging character in the measure of divergence, it must be weighted, and weighted so that it will have only a very minor effect on the measure as determined by the

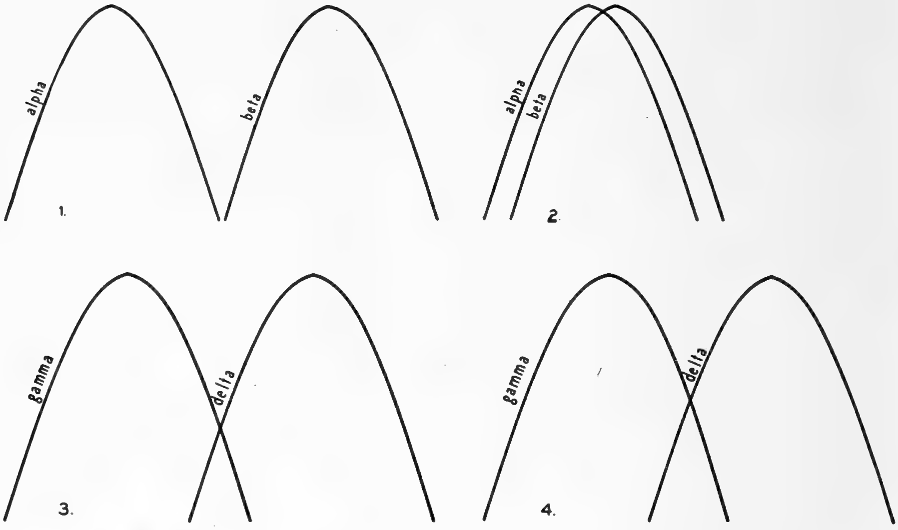

Fig. 1.—Graphic representation of frequency distributions of character A in two hypothetical populations, *alpha* and *beta*. Fig. 2.—Graphic representation of frequency distributions of character B in two hypothetical populations, *alpha* and *beta*. Fig. 3.—Graphic representation of frequency distributions of character C in two hypothetical populations, *gamma* and *delta*. Fig. 4.—Graphic representation of frequency distributions of character D in two hypothetical populations, *gamma* and *delta*.

single character showing the greatest divergence. The development of a satisfactory method of weighting to produce a pertinent index of divergence is problematical. It seems apparent that a measure of divergence based only on the character showing the greatest divergence is fairly adequate, although perhaps not altogether complete, as an expression of the relative divergence of the above two hypothetical pairs of populations.

It should not be difficult to find in nature examples approximately corresponding to the above hypothetical cases. The same order of reasoning may be applied to three or more characters, and to the untold multitude of actual cases that may be encountered in practice.

Measures that have been proposed based on a combination of several characters are unsatisfactory. A few examples of such measures are next cited and discussed.[2]

Physical anthropologists have been using such a measure, designated as the "coefficient of racial likeness." This was devised chiefly for use in cases in which only small samples are available, on the assumption that the study of many characters and the combination of the sum of their differences in a single figure will compensate for the paucity of individuals studied and yield comparative figures that would be more reliable than those based on the comparison of a single character (see Pearson, 1926). Of course, the same measure may be applied to samples of fair or large size. The formula in use for determining this measure depends chiefly on the following factors: (1) the difference between the means of any one character of the two populations compared, (2) the standard deviation, (3) the number of specimens in the samples, (4) the summation of the values for the separate characters, (5) division of the value obtained by the number of characters. When a sample is small the standard deviation determined by it is unreliable, and that of the nearest related population for which an adequate sample is available is employed on the assumption that anthropometric data usually have a nearly normal distribution and that there is not much difference between the standard deviations of the different populations.

Seltzer (1937) discusses some of the errors and fallacies inherent in the "coefficient of racial likeness" when used as a measure of di-

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[2] Students of the differing frequency distributions of blood groups in different populations of the genus *Homo* have been using a "biochemical index" or other indices to express population differences in terms of a single figure. These indices do not represent a combination of two or more characters, but a combination of percentage ratios of frequencies in the same distribution. As may well have been expected, such indices as well are inapplicable and sometimes misleading (see Wiener, 1935, pp. 153–154).

vergence, as follows: (1) For any given character, it assumes arbitrarily and unjustifiably a single standard deviation for different populations. (This objection may be overcome when the samples compared are of fair size, and the standard deviation of each population separately determined.) (2) It depends on the number of characters used in the comparison. (3) It depends on the number of specimens in the samples. (4) Fundamentally, it is not a measure of divergence, but rather an expression of probability. (5) What is most important of all, Seltzer shows that biologically it is altogether inapplicable, because it results in absurdly misleading conclusions. (The last three objections I raised in my 1938 paper in connection with the application of current formulae to a single character for the purpose of measuring divergence. The very fact that the coefficient of racial likeness is an expression of probability should lead one to expect that it will often result in false conclusions when used as a measure of divergence.)

Much simpler methods of combining several characters have been employed by some students of fishes in comparing populations or samples. Hubbs and Whitlock (1928, p. 471) compare two samples by determining the value of a ratio the numerator and denominator of which represent the products of measurements of certain parts, respectively, of the head and body. Koelz (1929, p. 426) also uses a ratio to express, in part, the difference between two populations (designated by him as subspecies), but the numerator and denominator represent the sums of the numerical value of two measurements. Schultz and Welander (1934, p. 6) employ the simple addition of the number of anal, dorsal, and both pectoral rays to determine the difference between two species. Similarly, Hubbs and Kuhne (1937) employ the sum of the numbers of anal, dorsal, ventral, and pectoral rays and the scales to determine the difference between two populations (designated by them as subspecies). Schultz and Schaefer (1936, p. 5) go a step farther and compare certain populations by both the addition and subtraction of the numerical values of certain characters, and the same device is employed by Schultz and Thompson (1936, p. 74), by Schultz and Reid (1937), and by Schultz (1937, p. 19).

By any of the above devices of combining characters, the numerical value of the combination is determined for each individual separately. A frequency distribution may then be arranged based on the individual numbers thus obtained.

For the purpose of determining relative divergence, or the taxonomic rank of the particular pair of populations compared, the combination of characters as determined by the above workers is inapplicable because it will prove to be misleading in many cases. Its use as a measure of divergence is therefore excluded for this one reason, outside of any other consideration. It is readily conceivable that by the use of such figures in the form of frequency distributions, some races may be shown erroneously to diverge to a greater extent than some species. It should not be difficult to find examples in nature to prove the truth of this assertion.

Judged by the evidence presented in one of the papers cited above, that by Schultz (1937), the two populations compared, *Mallotus villosus* and *M. catervarius*, are evidently not more than races, or subspecies at the most. Schultz compares in detail a larger number of characters than usual in such cases. It is work done in a thorough manner by methods that will help us solve the species problem. It is unfortunate, therefore, that his frequency distribution tables were not published, so that we could judge the precise divergence of every character separately. However, judged by the summaries of his data presented, the ranges and the means, it seems evident that the two populations intergrade widely in every character. Yet, when a certain number of characters are combined, by addition and subtraction, a frequency distribution is obtained that even shows a gap between the two populations. It should be possible to obtain the same result with many pairs of races if they are studied in as great detail as Schultz studied the pair of populations mentioned.

Another important matter to consider in this connection is the number of diverging characters. Let us take, for instance, two populations, *epsilon* and *zeta*, whose divergence in one character is close to 100 percent, or, concomitantly, intergradation is close to zero; and suppose, furthermore, that they do not diverge very appreciably in any other character. Nearly every individual may thus be referred to either population by the single, widely diverging character, and the two populations are to be properly regarded as distinct species. Now, let us suppose two other populations, *eta* and *theta*, that differ by, say, ten diverging characters, and furthermore, that there is considerable intergradation in every character, so that divergence of any one character is not more than of racial magnitude. In that case the two populations are to be properly regarded as of racial rank only, yet if the numerical values of the several characters are combined by the methods employed by the above authors, the two populations may show a high degree of divergence, perhaps even a gap between them, higher than the divergence between populations *epsilon* and *zeta*. The two populations studied by Schultz, mentioned above, apparently constitute an example very similar to our hypothetical *eta* and *theta*.

The foregoing discussion relates chiefly to the device of combining the numerical value of characters by addition and subtraction. The same misleading results will be obtained by combining characters in the form of ratios or by division. A consideration of this manner of combining characters may be simplified by reducing it to its lowest terms, the combination of two characters. In the two hypothetical pairs of populations illustrated above, for instance, let us assume that character D differs in such manner that it has a greater numerical value in population *gamma* than in *delta*, that is, the left-hand curve in Fig. 4 represents *delta* while the right-hand curve represents *gamma*. Then, if we combine the two characters in the form $\frac{C}{D}$, it seems apparent that, for most specimens at least, the values $\frac{C}{D}$ will be relatively greater for *delta* than for *gamma*, than in the comparison of the values of C alone. (This will depend to some extent, in individual specimens, on the degree of correlation of the two characters in each one of the two populations; but in general, the above statement may be expected to hold.) Consequently, the two arbitrary frequency distributions obtained from the values $\frac{C}{D}$, representing *gamma* and *delta*, respectively, will evidently show a greater divergence than either C or D taken separately. On the other hand, if we suppose that the numerical value of the characters A and B remain as illustrated, then the arbitrary distributions obtained by the combination $\frac{A}{B}$ will likely show a lesser degree of divergence than that shown by the divergence of character A when considered by itself. In other words, by combining the two characters in each pair of populations as indicated, *gamma* and *delta* may show a higher degree of divergence than *alpha* and *beta*, evidently a misleading result. When the numerator or denominator, or both, are, in their turn, made to represent a combination of more than one character, by addition, subtraction, or multiplication, things become more complicated, but it is apparent from the foregoing discussion that combining characters in such manner will often result in misleading conclusions.

Such combinations of characters by addition, subtraction, multiplication, and division of their numerical values, when carried to their extreme as is done in some of the papers cited above, on the whole give the impression of a mere manipulation of figures rather than that of sound statistical treatment of the data. This impression appears justified by the misleading results that are apt to occur. Fundamentally, what taxonomists are actually doing in distinguishing species, subspecies, or races, either by a numerical combination of several characters or by a consideration of every character separately, is to determine the relative degree of divergence; although this idea is often lost sight of on superficial thought. Our basis of comparison is, of course, always a single pair of populations. We determine to what degree a pair under consideration diverges and compare this divergence in relation to divergences shown by other pairs, either in a definite manner as I (1938) have suggested, or by rule of thumb as is usually done in taxonomic practice. That is just what most of the above-mentioned authors set out to accomplish, to determine by combining several characters the relative divergence of their populations, for the purpose of deciding whether they represent distinct species or categories of lower rank. For this purpose, their device of combining several characters is altogether misleading. What is particularly misleading in the use of such devices is that the arbitrary frequency distribution obtained as a result of the combination of the several characters may be treated by the ordinary statistical methods—as, indeed, a wholly mythical frequency distribution may be treated—to determine the value of the standard deviation, the probable error, the probability ratio, etc. Such treatment, seemingly, covers the figures with a cloak of statistical respectability, so to speak; it gives them a seeming validity. But, biologically, for the purpose of determining relative divergence, the figures are misleading, as discussed.

The foregoing devices of combining characters, in their extreme form, are carried to a point where they constitute almost a *reductio ad absurdum* going to prove their inapplicability. One is then compelled to reexamine the entire question more fully and work backward to the more simple forms. As a consequence, the applicability of some proper appearing, simple methods of combining characters is cast in doubt. For instance, it is the general impression among taxonomists that it is proper to use a ratio of two given measurements for the purpose of distinguishing species or populations of lower rank. I have used this method for distinguishing *Gobiosoma bosci* from *G. robustum* in my revision of their genus, and I used (1938) that comparison as one of the examples in establishing a gradual series of relative divergences. I (1929, p. 80) have also used the same method, in part, in comparing two populations of *Cynoscion.* Other taxonomists, and physical anthropologists in particular, sometimes use character indices in the form of a ratio based on the numerical value of two measurements. Doubt is now cast on the propriety of treating the data in this manner for the purpose of determining relative divergence.

From this point of view, one of the general, basic methods of fish taxonomy needs a reappraisal. Measurements of various parts are generally used in distinguishing populations of fishes of specific or lower rank. The measurements are generally stated not as absolute values, but as the numerical value of a ratio, generally as entering so many times in the standard length (that is the combined length of head and body), or in the head. Sometimes a ratio is stated in percentage form. This method is adopted because measurements differ with the size of the individual, and consequently absolute measurements would often be of limited value unless they were based on individuals of approximately the same size. At any rate, measurements as generally employed in distinguishing populations of fishes are used as a combination of two characters. In view of the foregoing discussion, it may be asked, Do they form a legitimate basis for the determination of relative divergence?

It is well to emphasize here the distinction between two ideas or processes, namely, identification and determination of relative divergence. A combination of the numerical values of two or more characters to form an index may be useful in identifying specimens. However, identification is not the only function of taxonomy. By a comparative study of morphology taxonomists are also trying to interpret relationship. And what is of greater immediate importance, they are classifying populations into categories—species, subspecies, races, etc. For the latter purposes we need to determine relative divergence as precisely as possible, and for this determination the combination of the numerical values of several characters will often prove misleading. These values may be shuffled so that a pair of races may show a greater degree of divergence than a pair of species, and a pair of closely related species a lesser degree of divergence than a pair of races compared. It remains to be determined to what extent and how often the combination of two characters in the form of a ratio, such as the cephalic index of physical anthropologists, or the manner of expressing measurements employed by fish taxonomists, may be used in expressing relative divergence and how often it will be misleading for this purpose.

It has been stated above that for the purpose of a precise determination of relative divergence, the principal character constitutes a basis for an adequate measure with respect to time and fairly adequate with respect to extent. Not only that, but the foregoing discussion makes it evident that it is the only proper basis now available. It is doubtful whether the other characters are to be considered at all in determining the measure of divergence, and in any case they should be afforded a very minor weight. The proper basis of determining such weights is not apparent now. In determining relative divergence every character must be considered separately, and apparently the best we can do now is to consider the other characters in a general way, in pairs of populations standing near the border line between the species and the subspecies, or the subspecies and the race, as determined by the principal character, as was suggested in my 1938 paper. The proper consideration of the other characters in this manner will, of course, depend on the thoroughness, skill, insight, and intuitive capacity of the taxonomist.

Other difficulties in the way of combining several characters appear altogether insurmountable. One of these is the possible existence of unequal numbers of diverging characters as between two or more given pairs of populations. This point has been raised above and hypothetical examples cited. Let us suppose further that one pair diverges in ten and another in twenty characters. Apparently, by combining all the characters in both cases, the two measures thus obtained will not express fairly the relative divergence of those two pairs of populations. To limit ourselves to a certain definite and equal number of characters in both pairs, as is done by Morant (1928), for instance, is a wholly arbitrary procedure; because on the assumption that the other characters, besides the principal one, are of importance in determining the measure of divergence, they should all be included in a determination of that measure for any one given pair of populations.

Another insurmountable difficulty is that it is practically impossible to study all characters. This is especially true if we are to include measurements of the head, body, or separate organs, or parts of the head, body, or organs, or the distance between any two given points, measurements by which distinct populations usually differ more or less. The number of such characters may be almost indefinitely increased. In practice, therefore, the number of characters studied necessarily must be limited, and the determination of divergence somewhat incomplete as far as it relates to the minor characters.

From the foregoing discussion the conclusion is reached that the principal character forms a fairly adequate basis for a measure of divergence of a given pair of populations, which may be used in determining relative divergence in a series of pairs. It is the only appropriate basis now available. The other characters, if considered at all for this purpose, should be given very minor weights. In any case, it is practically impossible to include all the minor characters.

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PALEOBOTANY.—*Fossil plants from the Cretaceous of Minnesota.*[1]

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In part 1 of volume 3 of the Final Report of the Geological and Natural History Survey of Minnesota there appeared a paper on the fossil plants prepared by the veteran paleobotanist Leo Lesquereux. This was published in 1895, and in it he identified 28 species of fossil plants, most of them well-known Dakota sandstone forms. He stated that they were entrusted to him for description by N. H. Winchell, the State geologist. The bulk of the material came from the banks of the Cottonwood River near New Ulm, but several are recorded from Mankato and from Goodhue County.

If the reader will consult the small scale geologic map that forms the frontispiece of the volume he will observe that considerably more than the western half of the State was thought to have been submerged by the eastern borders of the waters that flooded the great Colorado geosyncline during Middle and Upper Cretaceous times, and it has always seemed strange that no local geologist or paleontologist has been inspired to cultivate this field in the more than two score years since Lesquereux penned his report.

In January 1938, I received from Dr. F. M. Carpenter, of the Museum of Comparative Zoology at Cambridge, two specimens that had been submitted to him by Prof. Clarence Nickel, of the University of Minnesota. The specimens had been collected by Ludwig Koelnau, one-half mile north of Springfield, Brown County, Minn., and with the idea that they might represent some sort of an insect larva or pupa had been submitted to the Entomology Department of the University.

This locality is not far from the Big Cottonwood outcrop from which the bulk of the material came that was described by Lesquereux. My great interest led to Prof. C. O. Rosendahl's sending me in February of last year a small collection made from the Big Cottonwood outcrop, which is about 1 mile southwest of Springfield.

In addition to the pod mentioned above, there are several other things not before found in the Dakota of Minnesota, so that it is quite apparent that detailed and persistent exploration of this horizon would add considerably to the Cretaceous flora of Minnesota.

This brief note seems distinctly worth while to call attention to this neglected field aside from what it adds to our knowledge of mid-Cretaceous plants.

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[1] Received March 1, 1939.

Capsulocarpus dakotensis, gen. et sp. nov. Figs. 1–4

As will be realized from what follows, the nomenclatorial problem raised by the present specimen is perplexing, and I have reached a tentative solution by proposing the botanically noncommittal pseudogenus *Capsulocarpus* in order that there may be a name for these objects. For the present it has the features of the type species, which may be characterized as follows:

Podlike capsule, which, from the nature of its outer surface, was probably indehiscent. Somewhat falcate in outline, abruptly pointed distad, narrowed to a short and stout peduncle proximad, inflated and circular or inflated lenticular in cross section, filled with approximately circular thin seeds at right angles to its axis. This appearance may not represent seeds but may be due to the transverse direction of the fibrous inner wall of the capsule, the suggestion that it may be due to the edges of seeds being furnished by certain existing forms in the family Bignoniaceae. An external impression of the capsule is furnished by the counterpart of the specimen shown in Figs. 1 and 3. This is marked by a series of shallow oblique curved ribs and depressions roughly parallel with the convex side which are rather sharp and distinct on this convex side, but which diminish in magnitude and become obsolete about halfway toward the concave side. The whole organ is slightly under 5 cm in length and about 1.7 cm in width. If the bas relief shown in the specimen was symmetrical in life it was about 1.4 cm in thickness.

There is an undescribed specimen of what must be regarded as the same thing in the National Museum collections, which I owe to the courtesy of Dr. R. W. Brown and which comes from the Dakota sandstone 12 miles west of Lincoln, Nebr. This is somewhat smaller than the Minnesota specimen but shows the same falcate shape and transverse markings as the Minnesota specimen. This is about 3 cm long and 7 or 8 mm in maximum width and at most could be considered a second species of the same genus. For the present there seems to be no ground for regarding it as a distinct species, particularly in view of the following: Lesquereux in 1868 described from the Dakota sandstone at Decatur, Nebr., what he called *Pterophyllum haydenii.*[2] In his Cretaceous Flora[3] he published figures, and in 1883 and 1892 he referred to it as *Podozamites haydeni.*[4] The original of Lesquereux's figure 6 can no longer be found, but I have before me the original of his figure 6b. This, although somewhat compressed and otherwise poorly preserved, is exactly like the Minnesota specimen and approximately of the same size. The artist has emphasized a series of parallel longitudinal lines in keeping with what should be seen in a cycad pinnule (such as Lesquereux thought the specimens to be) and has entirely ignored the much more prominent transverse lines like those shown in the Minnesota specimen (Fig. 1). Lesquereux's specific name has not been taken up for the present species because it also included later discovered remains, which he subsequently regarded as a species of *Abietites,* so that if I have violated the canons of

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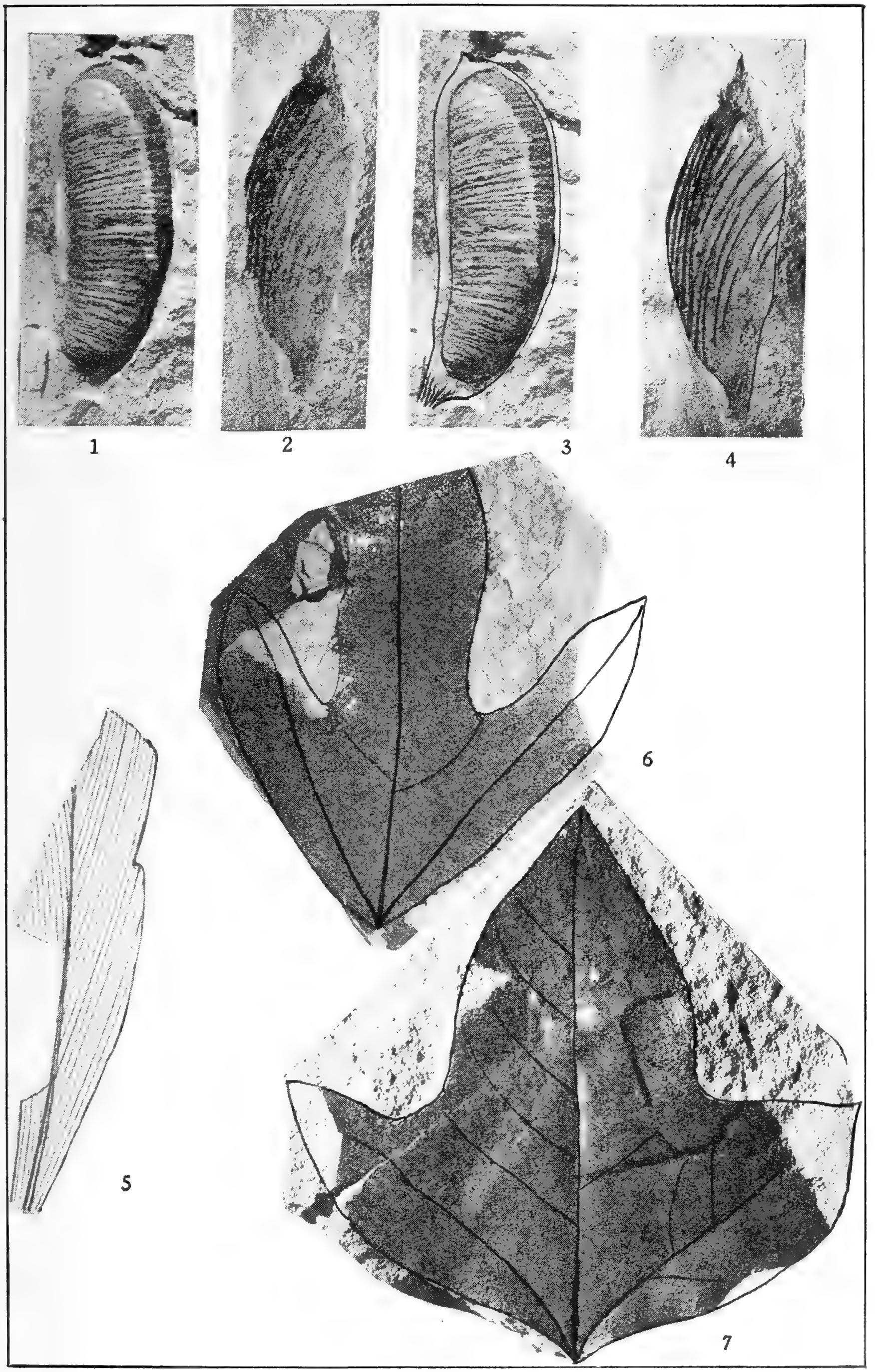
[2] LESQUEREUX, L. Amer. Journ. Sci. **46**: 91. 1868.
[3] —— U. S. Geol. Surv. Terr. **6**: 49, pl. 1, figs. 6, 6b. 1874.
[4] —— Ibid. **8**: 27. 1883; U. S. Geol. Surv. Mon. **17**: 26. 1892.



Figs. 1–4.—*Capsulocarpus dakotensis* Berry, n. sp. 1 and 3 the inner part, 2 and 4 the impression of the outer surface. 1 and 2 are from untouched photographs. Fig. 5.—*Protophyllocladus subintegrifolius* (Lesquereux) Berry. Figs. 6, 7.—*Sassafras acutilobum* Lesquereux.

nomenclature, some taxonomic purist may have the pleasure of changing my proposed name. The really important fact is that an identical species occurs in both Minnesota and Nebraska and that the supposed cycad in the Dakota sandstone flora, *Pterophyllum* and *Podozamites*, goes into the discard and disappears from paleobotanical literature.

Regarding the possible botanical relationship of these fossil fruits the story is about as involved as is the taxonomic one.

The present specimens at once suggested comparisons with a form described first in 1878 by Lesquereux and called *Carpolithes arachioides,* and subsequently changed to *Leguminosites arachioides* from a fancied resemblance to the modern peanut (*Arachis*). This form has been found at a score of localities near the Cretaceous-Eocene boundary throughout the Western United States and Canada and in the lower Eocene of the Mississippi embayment. The largest of these are only about one-half the size of the present specimens[5] and occur in racemes. They are similarly inflated and ornamented with longitudinal and transverse markings, and similar but smaller forms were described by me in 1930 as *Leguminosites arachioides minor*[6] and by Knowlton from the Denver formation of Colorado as *Berrya racemosa.*[7]

Meanwhile Brown[8] has discussed the question of the botanical relationships of these objects, and has shown that they are related to the existing Asiatic genus *Cercidiphyllum,* to which many of the early Tertiary leaves described as *Populus* are also related. Brown's proof, which I regard as conclusive, consists in finding at scores of localities the leaves in association with the capsules and characteristic tiny winged seeds. In a paper now in press, which I have been privileged to read, he gives complete details.

At first I was disposed to consider the Minnesota capsule as closely related to these trochodendraceous forms, but its large size, different habit, and different external ornamentation, as well as the possibility that the ornamentation of the inner capsule (Figs. 1 and 3) might indicate a column of disk-like seeds, suggested caution, and at present I am unable to suggest its botanical affinity. I doubt if it belongs to the Leguminosae and believe it will be found to represent some genus, perhaps an extinct one, of the family Bignoniaceae.

In connection with this material attention should be called to an object described by Newberry from the Raritan formation of New Jersey under the name of *Tricarpellites striatus.*[9] His figure 9 is especially like the external impression of *Capsulocarpus dakotensis.*

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[5] See BERRY, E. W. U. S. Geol. Surv. Prof. Paper **91,** pl. 48, fig. 9. 1916.

[6] BERRY, E. W. U. S. Geol. Surv. Prof. Paper **156:** 89, pl. 14, figs. 2–6. 1930.

[7] KNOWLTON, F. H. U. S. Geol. Surv. Prof. Paper **155:** 134, pl. 41, figs. 4, 5. 1930.

[8] BROWN, R. W. Journ. Pal. **9:** 575, pl. 68. 1935.

[9] NEWBERRY, J. S. U. S. Geol. Surv. Mon. **26:** 132, pl. 46, figs. 9–13. 1895.

Protophyllocladus subintegrifolius (Lesquereux) Berry Fig. 5

The usually incomplete leaves or phyllodes of this species are the most abundant in the collection studied. Described first by Lesquereux[10] from the Dakota sandstone of Kansas and Nebraska as a fossil species of *Phyllocladus,* it was recorded from the Atane beds of western Greenland by Heer under the name of *Thinnfeldia lesquereuxiana.*[11] Newberry reported it from the Raritan formation of the Amboy district in New Jersey, and still later it has been found to be of common occurrence in the Magothy formation of the Atlantic Costal Plain, in the Tuscaloosa formation of Alabama, in the Frontier formation of Wyoming, in the Cretaceous of Alaska, and in Russian Sakhalin. Meanwhile other species have been described from Alaska, the Western United States, and Patagonia.

The Minnesota specimens are perfectly characteristic. Its botanical affinities have been much discussed.[12]

Sassafras acutilobum Lesquereux[13] Figs. 6, 7

Also relatively abundant in the present collection are leaves that are indistinguishable from this species, first described by Lesquereux in 1874 from the Dakota sandstone of Kansas, and since recorded from numerous additional localities, especially along the Atlantic and Gulf borders from Marthas Vineyard to Alabama in the Raritan, Magothy, and Tuscaloosa formations.

Lesquereux described many species of *Sassafras* from the Dakota, and other similar lobed leaves as various species of *Araliopsis, Platanus, Cissites,* and *Sterculia.* Their generic relations are extremely tangled and overlapping. Some of these are certainly related to *Sassafras* and some are not. The geological history of the genus is treated at some length by the present writer, to which account the reader is referred.[14] The Minnesota specimens are identical with those of the type from the Dakota sandstone. Any extended discussion is not pertinent in the present note and would be endlessly complicated by the jealousies growing out of the rivalry between Lesquereux and Newberry and the feeling engendered by the establishment of the U. S. Geological Survey and the liquidation of the Hayden Survey. While this rivalry was not so venomous as that between Cope and Marsh in the vertebrate field, it resulted in similar, if somewhat less marked, taxonomic tangles.

Laurus plutonia Heer

Several specimens of this quondam species are present in the present collection. It was first described by Heer from the Dakota sandstone of

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[10] LESQUEREUX, L. Amer. Jour. Sci. **46**: 92. 1868.
[11] HEER, O. Flora fossilis Arctica **6**(2): 37. 1882.
[12] See BERRY, E. W. Bull. Torrey Bot. Club **30**: 440. 1903.
[13] A fairly complete synonymy is given by BERRY, E. W. Maryland Geol. Survey. *Upper Cretaceous,* p. 866. 1916.
[14] BERRY, E. W. *Tree ancestors,* pp. 247–251. 1923.

Kansas and was doubtfully recorded by Lesquereux from New Ulm, Minn. It has also been recorded from a large number of Upper Cretaceous localities in West Greenland, along the Atlantic border of the United States from Marthas Vineyard to Alabama and Texas. The name *Laurus* does not imply a close relationship with the existing Old World species of *Laurus*, but it has been used by paleobotanists in the sense that a few wiser authors have used the pseudogeneric term *Laurophyllum*, implying some undetermined genus in the family Lauraceae.

ZOOLOGY.—Onychocythere, *a new genus of marine ostracod from Florida, with a description of one species.*[1]

WILLIS L. TRESSLER, University of Buffalo. (Communicated by WALDO L. SCHMITT.)

Two specimens, a male and a female, of this ostracod were sent to the writer by Dr. Waldo L. Schmitt, curator of marine invertebrates, U. S. National Museum, for identification. They were collected by Miss Louella E. Cable from the stomach of a shad caught at Welaka, Fla., in the St. Johns River on April 1, 1938. The shad (*Alosa sapidissima*) had a total length of 478 mm and a standard length of 327 mm. There was very little food in either the stomach or intestine, as is the case with most of the adult shad examined. In the summer of 1936, two collections of shad totaling 58 specimens were taken from the Hudson River and were found to have been feeding on surface drift exclusively (Tressler and Bere, 1937). In the Florida shad the stomach contents amounted to only 4.0 cc, most of which consisted of tiny bits of plant material, rotted leaves, twigs, and grasses. In addition there were 30 copepods identified by Dr. C. B. Wilson as *Mesocyclops leuckarti* (Claus), 1 nematode, 4 daphnia identified by Dr. C. Juday as *Daphnia longispina* var. *hyalina*, 1 chironomous larva, 1 minute crab leg, and 6 ostracods. The ostracods consisted of the two specimens mentioned above and four specimens of *Cypria opthalmica*, a common fresh-water species. The shells of the marine ostracods were somewhat disintegrated (this was particularly true of the shell of the female), while those of *Cypria* were well preserved. It seems likely, therefore, that the marine ostracods had been in the stomach for some time before the fresh-water forms had been eaten. The calcareous shell is fairly resistant to the action of weak acids, and evidently the gastric juice requires a considerable period of time before the contents are available as food. The exact location of the habitat of this ostracod is, of course, indeterminable, but as the vast majority

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[1] Received March 18, 1939.

of the family Cytheridae and all the known members of the subfamily Cytherinae are marine, it is logical to suppose that the shad had fed upon them in the ocean before entering the St. Johns River. All the members of the family Cytheridae are almost entirely devoid of natatory powers and are, as a consequence, strictly bottom dwellers. *Cypria*, on the other hand, is a very agile swimmer although many of the species keep close to the bottom.

The slides of the dissected ostracods have been deposited in the U. S. National Museum as type specimens.

Suborder PODOCOPA Sars

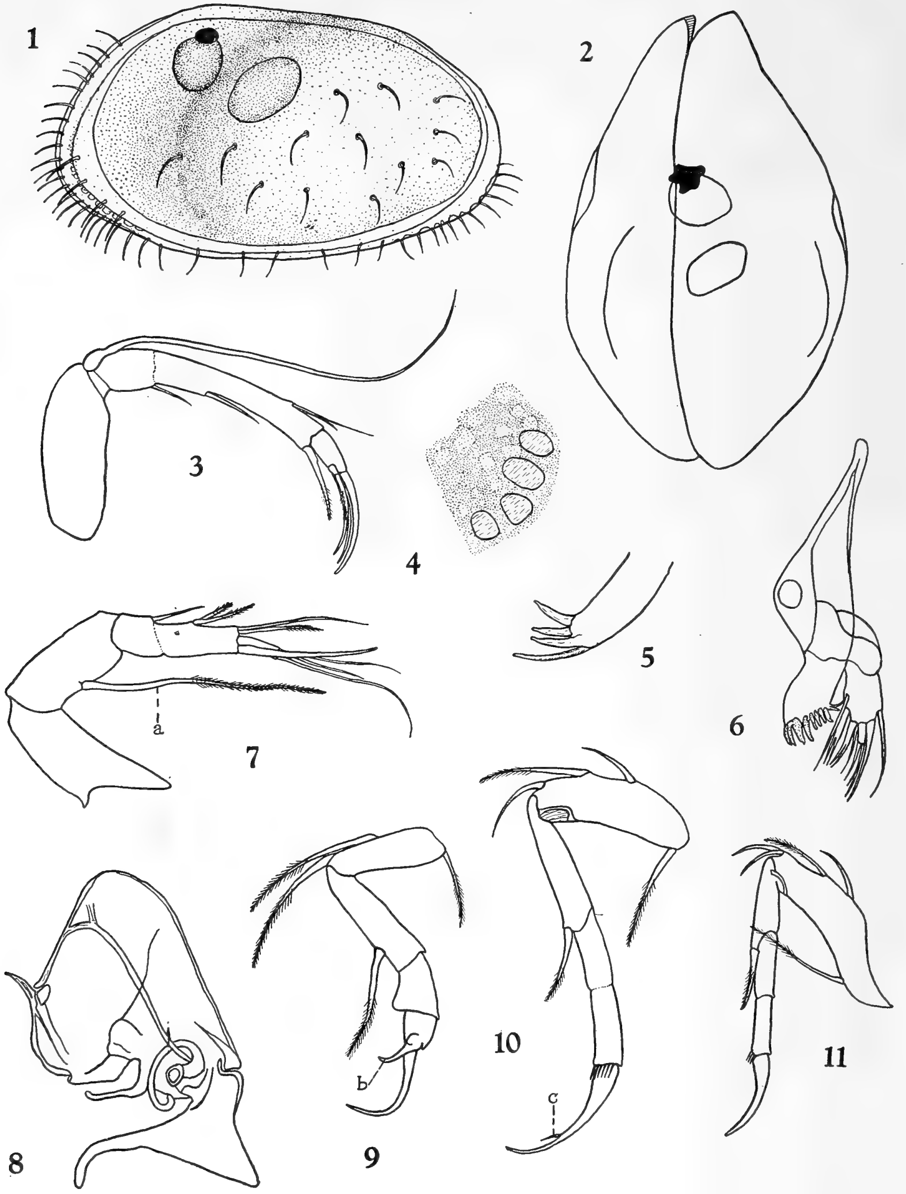
Family CYTHERIDAE Baird

Subfamily Cytherinae Sars

This subfamily was proposed by Sars (1928) to include the more typical Cytheridae; those closely allied to the genus *Cythere*. The shell is of very firm consistency and calcareous with a more or less sculptured surface, which may or may not bear projections or spines. Both of the antennae are strongly developed; the anterior antennae have 3 or 4 joints and possess 2 or 3 claw-like spines with several thinner bristles in between. The legs are normally developed in all the previously described genera and are of the same appearance in both sexes. The new genus described here departs from the usual conditions found in the characteristics of the thoracic legs of the subfamily Cytherinae, but as it seems to conform in all other major respects most closely to this group, it appeared best to include it here.

Onychocythere, n. gen.

Generic characters.—Shell of rather firm consistency but without sculpturing or projections. Surface of valves with a few very coarse scattered spines. A comparatively clear marginal zone at the anterior end bears numerous coarse spines. The posterior border is much narrower and has fewer and somewhat finer bristles. Seen from the dorsal side, the shell is rather tumid, the anterior extremities narrowing down from a point about two-thirds of the distance from the posterior margin. Eye, conspicuous and single. First antennae of normal appearance except for a very long and robust bristle, which arises from the posterior border of the second segment and which is coarsely haired throughout its distal half. Second antennae of normal appearance with a long tapering flagellum. Maxillae with masticatory lobes produced, the palp with three stout unarmed claws and a somewhat longer and more slender spine. Thoracic legs unequally developed and possessing several remarkable and apparently unique features which are sufficient to readily identify this genus. First leg, short and of normal appearance. Second leg, much the longest, with a thick terminal claw, which bears a peculiar aberrant bristle about one-third the length from the distal end on the posterior border. Third leg, short and heavily built with a recurved, slender terminal claw and a second short, heavy claw at its base. No differentiation of the legs in the two sexes.



Figs. 1–11.—*Onychocythere alosa*, new genus and species. 1, Lateral view of left valve of male. 2, Dorsal view (slightly tilted) of male. 3, Second antenna of female. 4, Muscle marks and detail of shell markings, female. 5, Spines of palp of masticatory lobe of maxilla of female. 6, Mandible of female. 7, First antenna of female. 8, Copulatory apparatus of male. 9, Third thoracic leg of female. 10, Second thoracic leg of female. 11, First thoracic leg of female.

Onychocythere alosa, n. sp. Figs. 1–11

Specific characters.—Female: Shell of oval shape, seen laterally, with broadly rounded ends, the anterior somewhat more broadly rounded than the posterior. Greatest height anterior to the middle. Ventral margin convex. Hyaline border widest anteriorly. Surface of valves without sculpturing but marked with a very delicate pattern of polygonal areas bordered by darker margins. The anterior margin gives rise to a number of very coarse bristles, which are also sparsely scattered over the surface of the valves. Posterior border with smaller and fewer bristles. Seen dorsally, oval in outline; greatest width in the center. Anterior ends attenuated; posterior broadly rounded. Eye spot, single and conspicuous. Valves nearly equal, the right being slightly longer than the left. First antenna of normal shape for this group except for a very long and heavy spine originating from the posterior border of the second segment (Fig. 7, *a*). Terminal half of spine coarsely haired. Second antenna with a long tapering flagellum. Palp of masticatory lobe of maxilla with three stout unarmed claws and a heavy spine. Legs much differentiated, the first being the shortest and least developed. The second leg is the longest and terminates in a heavy, slightly curved claw, which bears near its tip and aberrant bristle (Fig. 10, *c*). At the base of the terminal claw is a row of six short bristles. The third leg is by far the most highly developed of the three and, while shorter than the second, is very stout and bears a strongly recurved tapering terminal claw. At the base of the terminal claw is a second heavy, short claw (Fig. 9, *b*). The bristle on the posterior margin of the second segment is very heavy and is densely haired on its distal half.

Male: Shell of similar size and shape to that of the female. Bristles much coarser. Internal structure almost identical with that of the female, including the structure of the three thoracic legs, which show the same features found in the other sex. Copulatory apparatus very large, with the basal portion rounded triangular in shape. Below, it sends off a slight, short, nearly straight projection, which is slightly hooked at its extremity. Inside it is provided with a very much curled, thick cord. Terminal portion with a slightly blunt posterior end and a much elongated anterior projection which curves ventrally near the extremity.

Color of shell undetermined.

Length of adult female, 0.91 mm. Length of adult male, 0.99 mm; height, 0.54 mm; width, 0.61 mm.

Occurrence.—Taken from the stomach of a shad caught in the St. Johns River at Welaka, Fla., on April 1, 1938. Female holotype, U. S. N. M. no. 77805. Male paratype, U. S. N. M. no. 77806.

Remarks.—This genus seems most closely allied to the genus *Cythere*, in its modern restricted sense, and agrees with it in the general conformation of the shell and in most of the internal parts. The remarkable differentiation of the thoracic legs, particularly that of the third leg, which seems to be unique in the literature, makes it seem necessary to establish a separate genus.

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Tressler, W. L., and Bere, Ruby. *A limnological study of some lakes of the Lower Hudson area.* Suppl. 26th Ann. Rep. New York State Cons. Dept. **8**: 249–263. 1936.

ENTOMOLOGY.—*A new genus of Trypetidae near* Anastrepha (*Diptera*).[1]

ALAN STONE, U. S. Bureau of Entomology and Plant Quarantine.

A study of species heretofore placed in the genus *Anastrepha* has revealed a number that differ rather widely in structure from the genotype. Certain of these belong to the subgenus *Pseudodacus* Hendel, which I believe to be worthy of generic status and which I shall treat in a later paper. The others I place in the genus described in this paper. Eight previously described species and three new ones are included.

Certain terms in this paper may require explanation. The *wing pattern* is considered to consist of three bands, which become somewhat coalescent in certain species, broken or incomplete in others. The *costal band* extends along the anterior margin from the base of the wing to the apex of vein R_1; the **S**-band and the **V**-band are as designated by previous writers. The *ovipositor* is a sclerotized, subcylindrical tube with an acute apex, lying in a cylindrical, tapering, *ovipositor sheath*, the seventh abdominal segment. The eighth abdominal segment is membranous, is invaginated into the end of the ovipositor sheath, and bears denticles dorsally which form the *rasper*. Since the abdomen is often bent in mounted specimens, the total length of the body is difficult to determine. For this reason I have used instead, to indicate the size of the species, the length of the mesonotum from its anterior margin to the apex of the scutellum.

The writer is particularly indebted to A. C. Baker, of the Division of Fruitfly Investigations, Bureau of Entomology and Plant Quarantine, who first proposed the segregation of this genus, for specimens of the two new Mexican species; to James Zetek of the same Division for the new species from Panama; to John Smart, of the British Museum, for valuable information on the type of *Trypeta acidusa* Walker; and to A. da Costa Lima, of the Instituto Oswaldo Cruz, Rio de Janeiro, for information on a number of his species.

Lucumaphila, n. gen.

Agreeing in structure and chaetotaxy with *Anastrepha* (type, *Dacus serpentinus* Wiedemann) except for the following: Ovipositor sheath more slender; denticles of rasper usually all minute, long hooks absent, or, if the denticles are longer (0.1 mm), straight with blunt apices, not hook-shaped; ovipositor extremely slender, subcylindrical, the shaft about 0.05 mm or less in diameter; claspers of male rounded apically, the teeth subapical; aedeagus very slender, 1–2 mm long, reaching well beyond apex of claspers but considerably shorter than ovipositor; tip of aedeagus simple, membranous.

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[1] Received March 29, 1939.

Genotype.—Lucumaphila sagittata, n. sp.

Distribution.—Neotropical Region from the Rio Grande Valley, Tex., to Brazil. The host fruits of only two species are known, both belonging to the genus *Lucuma* of the family Sapotaceae.

The species are medium sized to rather large and predominantly yellow-brown in color. The wing pattern is essentially similar to that found in many species of *Anastrepha* and not reduced or modified as in *Pseudodacus.* The microchaetae usually present on the dorsal surface of the posterior portion of the alula in *Anastrepha* are absent in *Lucumaphila.* All but one species of *Lucumaphila* (*hamadryas*) has, in the female, a distinct, small, dark nodule dorsally on the eighth segment just distad of the end of the ovipositor sheath. Certain species of *Anastrepha* have the ovipositor nearly as slender as in the genus *Lucumaphila,* but in these species it is never both extremely slender and very long and the rasper is always well developed. In *Lucumaphila hamadryas,* new species, the denticles of the rasper are unusually large for the genus, but they are straight and blunt, not curved and tapering as in *Anastrepha,* and they differ only in size from the minute denticles of the other species of *Lucumaphila.* The modified wing pattern and large hooks of the rasper distinguish the females of *Pseudodacus.* The male terminalia in *Lucumaphila* are much as in *Pseudodacus,* but the aedeagus of *Pseudodacus* is always very much reduced, scarcely exceeding the claspers. In those species of *Anastrepha* in which the teeth of the male clasper are subapical, the aedeagus is always much stouter and longer than in *Lucumaphila.*

Within the genus *Lucumaphila* the male terminalia exhibit very few differences, at least in those species known to the writer. The aedeagus is 1 to 2 mm long, the exact measurement being very difficult to make. The distal portion is slightly enlarged, with the apex attenuate and without the sclerotized modifications present in *Anastrepha.* The claspers are very similar in most of the species, but in the three species the males of which are known to me a sclerotized structure at the junction of the claspers, at the point where the anal segment joins the clasper segment ventrally, shows some differences. This structure is figured, but its value can not certainly be determined until more specimens can be studied.

The ovipositor tip is sagittate in several species, but the character is frequently difficult to see because the extracted, mounted ovipositor tends to lie on its side or will turn on its side even after mounting. Also, the ovipositor is so slender and delicate that extracting it without breaking off the tip is difficult.

KEY TO SPECIES

1. Costal and **S**-bands of wing widely separated 2
   Costal and **S**-bands of wing touching to broadly confluent 3
2. Ovipositor shaft about 0.025 mm wide, the tip very slender; two brownish spots on posterior margin of mesoscutum; **V**-band broken anteriorly ....1. *luederwaldti* (Costa Lima)
   Ovipositor shaft about 0.05 mm wide, the tip broader, with fine serrations; no dark spot on posterior margin of mesoscutum; **V**-band complete ....2. *hambletoni* (Costa Lima)
3. Bands on apical half of wing broadly confluent and somewhat diffuse; cell *R* completely infuscated ....3. *obscura* (Aldrich)
   V-band distinct; cell *R* partially hyaline 4

4. Mesoscutum with two or three distinct black spots on posterior margin.. ....4. *dentata*, n. sp.
   Mesoscutum not spotted with black, although a dark brown band or diffuse brownish spots may be present posteriorly................5
5. Costal and **S**-bands very broadly coalescent along vein R_{4+5}; the hyaline area in cell R greatly reduced; cell M infuscated; **V**-band narrowly joined to **S**-band at vein M....................5. *urichi* (Greene)
   Costal and **S**-bands joined more narrowly along vein R_{4+5}; the hyaline area in cell R larger; cell M hyaline; **V**-band separated from **S**-band at vein M...6
6. **V**-band separated from **S**-band; denticles of rasper of female rather large, about 0.1 mm long..........................6. *hamadryas*, n. sp.
   At least proximal arm of **V**-band joined to **S**-band; denticles of rasper of female much smaller...7
7. Distal arm of **V**-band slightly narrower at wing margin than it is near anterior end; hind margin of **S**-band subparallel to proximal margin of inner arm of **V**-band from vein R_{4+5} to fold in cell first M_2....... ....7. *sagittata*, n. sp.
   Distal arm of **V**-band of uniform width, narrowed anteriorly, or greatly reduced, in any case usually disconnected from proximal arm; **S**-band and proximal arm of **V**-band divergent from near their juncture....8
8. Ovipositor sheath 8 mm long; macrochaetae of dorsum of thorax black; vein M_{1+2} but little turned forward at wing margin................ ....8. *longicauda* (Costa Lima)
   Ovipositor sheath less than 7 mm long; macrochaetae of dorsum of thorax orange-brown; vein M_{1+2} with the normal forward curve....9
9. Ovipositor sheath more than 5.5 mm long...........9. *hamata* (Loew)
   Ovipositor sheath about 4 mm long...........10. *zernyi* (Costa Lima)

Lucumaphila acidusa (Walker) would run to couplet 9 in this key, but since the ovipositor sheath and ovipositor are incomplete it can not be keyed further.

1. **Lucumaphila luederwaldti** (Costa Lima), n. comb.

Anastrepha luederwaldti Costa Lima, Mem. Inst. Oswaldo Cruz **28:** 510, figs. 15–16, pl. 66, fig. 18, pl. 76, fig. 67, 1934.

Medium sized, yellow-brown. A pair of castaneous spots on apical margin of mesoscutum; metanotum entirely yellow-brown. Macrochaetae pale yellow. Sternopleural bristle well developed. Wing 7.75 mm long, the costal, **S**-, and **V**-bands all separated and the **V**-band broken anteriorly, neither arm crossing vein R_{4+5}; vein M_{1+2} only slightly turned forward at apex. *Female:* Body, exclusive of ovipositor sheath, 6.5 mm. Ovipositor sheath 3 mm long, tapering. Ovipositor about 0.025 mm wide, the tip tapering and with no serrations. *Male:* Tip of clasper obtuse, turned slightly caudad, the teeth subapical.

Cotypes.—Two females, two males (Museu Paulista, São Paulo).

Type localities.—São Paulo, Ypiranga, and Alto da Serra, Brazil.

Distribution.—Known only from the foregoing localities, all in southern Brazil.

Remarks.—I have not seen this species, the above description being based upon the original one. The slender ovipositor and character of the rasper make its assignment to this genus rather certain.

2. **Lucumaphila hambletoni** (Costa Lima), n. comb.

Anastrepha hambletoni Costa Lima, Mem. Inst. Oswaldo Cruz **28**: 519, fig. 19, pl. 67, fig. 21, 1934.

Medium sized, yellow-brown, the mesoscutum with pale-yellow stripes. Total length, exclusive of ovipositor sheath, 7 mm. Macrochaetae castaneous. Sternopleural bristle present. Wing 7 mm long, the costal, **S**-, and **V**-bands all separated; **V**-band complete; vein R_{2+3} slightly undulant. *Female:* Ovipositor sheath 5 mm long, slender, tapering. Ovipositor long, slender, the shaft about 0.05 mm wide; tip narrowed rather abruptly, with a few fine serrations.

Holotype.—Female (Instituto Oswaldo Cruz, Rio de Janeiro).

Type locality.—Viçosa, State of Minas Geraes, Brazil.

Distribution.—Known only from the single specimen.

Remarks.—I have not seen this species, the above description being based on the original one. The dimensions of the body and wing were not given in the original description but have been furnished me by Dr. Costa Lima.

3. **Lucumaphila obscura** (Aldrich), n. comb.

Anastrepha obscura Aldrich, Proc. U. S. Nat. Mus. **66** (18): 5, 1925.—Greene, Proc. Ent. Soc. Washington **36**: 157, pl. 21, fig. 2, 1934.—Costa Lima, Mem. Inst. Oswaldo Cruz **28**: 500, 1934.

Large, orange-brown. Mesonotum 4.6 mm long, orange-brown, the mesoscutum with indistinct paler stripes; no black on metanotum. Macrochaetae orange-brown; pile yellow. Sternopleural bristle very weak. Wing (Fig. 10) 10.5 mm long, orange-brown, except for a hyaline triangle on costa beyond stigma and pale spots on posterior margin of wing in cells second M_2, Cu_1, and anal, the spot in Cu_1 extending forward faintly to vein R_{4+5}; in one specimen a fenestrate spot in cell R_{2+3} beyond costal hyaline spot. *Female:* Ovipositor sheath 6.5 mm long, the basal half somewhat swollen, tapering to the slender apical half; spiracles about 1.1 mm from base. Ovipositor 5.5 mm long, very slender, the shaft about 0.035 mm wide, slightly swollen before apex; tip as in figure 1. *Male:* Tip of clasper acute in lateral view. Cephalic view as in figure 7.

Holotype.—Female (U. S. National Museum).

Type locality.—Maraval, Trinidad.

Distribution.—Trinidad and Brazil.

Host plant.—*Lucuma multiflora.*

Remarks.—In addition to the original specimens there is a male from Trinidad, March 5, 1919 (F. W. Urich), in the U. S. National Museum and a female from Brazil (H. W. Bates) in the British Museum. The species is easily recognized by its wing pattern.

4. **Lucumaphila dentata,** n. sp.

Medium sized, yellow-brown, with black spots on mesoscutum. Mesonotum 3.58 mm long, pale yellow, the mesoscutum with four orange-brown stripes, the outer pair extending from behind humeri to lateral angles of scutellum, narrower posteriorly and coalescent with inner pair anteriorly; two inner stripes extending about three-fourths of distance from anterior margin to scutellum and separated by a median line which narrows anteriorly, leaving a transverse, pale-yellow area anterior to scutellum with a median projection to anterior margin of mesonotum and narrow lateral projections, fading out anteriorly; at posterior end of each lateral orange-brown stripe a black spot, concave on inner and anterolateral margins, convex on posterolateral margin; holotype and female paratype only faintly brownish on scutoscutellar suture medianly; male paratype with a pronounced brownish-black spot; pleura predominantly pale yellow; metanotum uniformly yellow-brown. Macrochaetae yellow-brown; pile yellow. Sternopleural bristle present, slender. Wing (Fig. 11) 8 mm long, the bands yellow-brown; costal and **S**-bands united a short distance on vein R_{4+5}; **V**-band complete, joined to **S**-band anteriorly. *Female:* Ovipositor sheath 2.6 mm long, evenly tapering apically; spiracles 0.67 mm from base. Ovipositor very slender, the shaft about 0.0175 mm wide; length unknown, as it is complete in neither female; tip as in Fig. 2. *Male:* Terminalia accidentally lost.

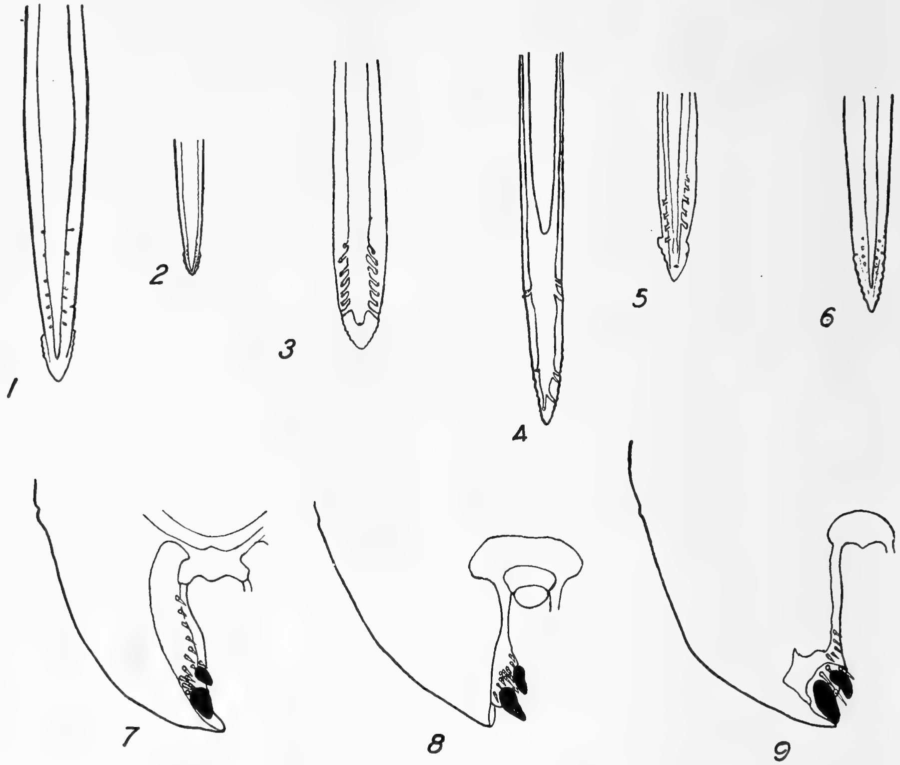

Fig. 1.—Ovipositor tip of *Lucumaphila obscura* (Aldrich). Fig. 2.—Ovipositor tip of *L. dentata*, n. sp. Fig. 3.—Ovipositor tip of *L. urichi* (Greene). Fig. 4.—Ovipositor tip of *L. hamadryas*, n. sp. Fig. 5.—Ovipositor tip of *L. sagittata*, n. sp. Fig. 6.—Ovipositor tip of *L. hamata* (Loew). Fig. 7.—Right male clasper of *L. obscura* (Aldrich). Fig. 8.—Right male clasper of *L. sagittata*, n. sp. Fig. 9.—Right male clasper of *L. hamata* (Loew).

Holotype.—Female. Paratypes, one male, one female (U. S. N. M. no. 51649).

Type locality.—Tequila, Jalisco, Mexico.

Distribution.—Jalisco, Mexico; Texas.

Remarks.—The holotype and male paratype formed part of the material obtained as a result of a trip by A. C. Baker and Alfons Dampf to Tequila in the latter part of July 1934. The name *dentata* is the manuscript name under which Dr. Baker figured the species in an unpublished report, chosen in reference to the toothlike black spots on the mesoscutum. The female paratype was collected at San Juan, Tex., February 20, 1935, by Burl Stugard. The ovipositor sheath of this specimen is the one described, as the sheath of the holotype was not preserved by Dr. Baker.

5. **Lucumaphila urichi** (Greene), n. comb.

Anastrepha urichi Greene, Proc. Ent. Soc. Washington **36:** 159, pl. 22, fig. 1, 1934.

Rather large, yellow-brown. Mesonotum 4.39 mm long. Entire thorax uniformly yellow-brown. Macrochaetae orange-brown; pile pale yellowish brown. Sternopleural bristle very weak. Wing (Fig. 12) 9.25 mm long, the venation normal; wing bands orange-brown, the hyaline area between apical portion of **S**-band and distal arm of **V**-band distinctly constricted at vein R_{4+5}; **V**-band broad, broadly connected with **S**-band anteriorly and narrowly so on vein *M;* costal and **S**-bands broadly coalescent; cell *M* infuscated. *Female:* Ovipositor sheath 4.87 mm long, the apical third distinctly narrower than the posteriorly tapering basal two-thirds; spiracles 1.33 mm from base. Ovipositor 4.25 mm long, extremely slender, the shaft about 0.029 mm wide; tip slightly widened, with the apex rounded and indistinctly serrate (Fig. 3).

Holotype.—Female (U. S. National Museum).

Type locality.—Trinidad.

Distribution.—Known only from the single specimen.

6. **Lucumaphila hamadryas,** n. sp.

Large, yellow-brown. Mesonotum 4.9 mm long. Mesoscutum pale yellow, with four rather indistinct orange stripes, the median pair not reaching to acrostichal bristles posteriorly; a darker orange-brown, transverse band in front of scutellum; scutellum and pleura pale yellow; metanotum orange-yellow. Macrochaetae black; pile pale yellow-orange. No sternopleural bristle. Wing (Fig. 15) 11.5 mm long, the pattern mostly brown, the costal and **S**-bands joined for a short distance on vein R_{4+5}; **V**-band rather heavy, narrowed but not broken at apex, narrowly separated from **S**-band. *Female:* Ovipositor sheath 6.5 mm long, slender, tapering, the spiracles about 1.34 mm from base. Ovipositor 5.53 mm long, the shaft about 0.035 mm wide, the base abruptly widened, the tip long, slender, with minute serrations apically (Fig. 4).

Holotype.—Female (U. S. N. M. no. 51650).

Type locality.—La Campana, Panama.

Distribution.—Known only from the type specimen.

Remarks.—The type was collected in a glass trap in Muñoz Grove, La Campana, January 7, 1939, by James Zetek, who wrote, "The single large female is the largest *Anastrepha* yet collected by us. . . ." As indicated previously, this species shows certain features of the eighth segment and

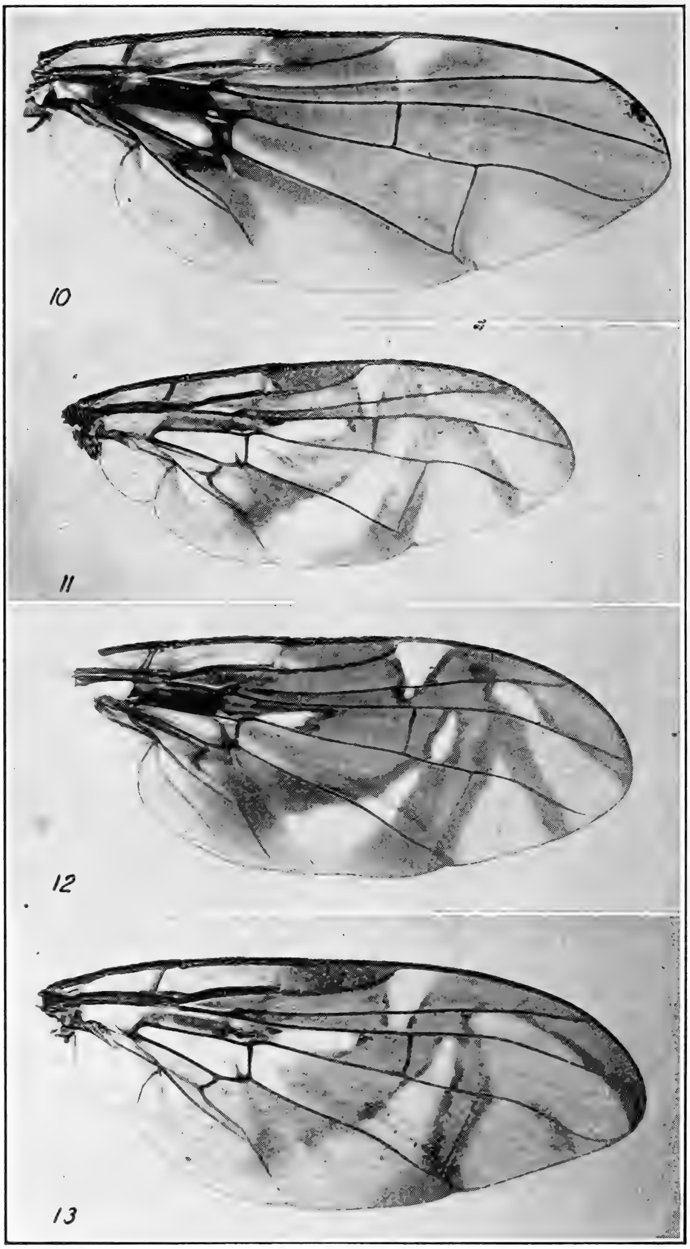

Fig. 10.—Wing of *Lucumaphila obscura* (Aldrich). Fig. 11.—Wing of *L. dentata*, n. sp. Fig. 12.—Wing of *L. urichi* (Greene). Fig. 13.—Wing of *L. hamata* (Loew).

rasper rather different from other species of the genus, but the shape of the rasper denticles and the character of the ovipositor place it in *Lucumaphila.*

7. **Lucumaphila sagittata,** n. sp.

Rather large, predominantly yellow-brown. Mesonotum 4.5 mm long. Mesoscutum orange-yellow, with humerus, a sublateral stripe from transverse suture to scutellum, and an area in front of acrostichal bristles having a narrow median extension anteriorly, pale yellow; a brown transverse band on scutoscutellar suture, most of it anterior to suture; pleura pale yellow; metanotum orange-yellow. Macrochaetae orange-brown; pile pale yellow. No sternopleural bristle. Wing (Fig. 14) 9.9 mm long, the pattern orange-brown, the costal and **S**-bands rather narrowly connected; **V**-band rather narrowly connected to **S**-band; distal arm of **V**-band widest just behind connection with the proximal arm, narrowing to the posterior margin. *Female:* Ovipositor sheath 4.5–5.2 mm long, slender, tapering, slightly curved upward, the spiracles about 1.11 mm from base. Ovipositor 3.9–4.5 mm long, the shaft about 0.028 mm wide; tip scarcely wider than shaft, sagittate (Fig. 5). *Male:* Clasper stout, the apex blunt in lateral view; cephalic view as in Fig. 8.

Holotype.—Female. Paratypes, 15 females, 5 males (U. S. N. M. no. 51651).

Type locality.—Cuernavaca, Mexico.

Distribution.—Texas to Panama.

Host plant.—According to Dr. Baker this species has been reared from the seeds of *Lucuma* in Mexico, but I have seen no reared specimens.

Remarks.—The holotype was trapped at Cuernavaca in September 1933 by M. McPhail; 15 paratypes were trapped at the same locality in September 1933 and November 1934; 4 paratypes were trapped at Mission, Tex., January 6, 1938, by D. O. Sikes; one paratype was trapped at Balboa, Canal Zone, in September 1938 by James Zetek. The name of this species, suggested by the strongly sagittate tip of the ovipositor, is the manuscript name under which Dr. Baker figured and described the species in an unpublished report.

8. **Lucumaphila longicauda** (Costa Lima), n. comb.

Anastrepha longicauda Costa Lima, Mem. Inst. Oswaldo Cruz **28:** 525, fig. 23, pl. 48, fig. 25, pl. 74, fig. 53, 1934; O Campo **8:** 38, 1937.

Large, yellow-brown. Mesoscutum yellow-brown with no pale stripes; metanotum with two brownish, transverse streaks on each side. Macrochaetae black. No sternopleural bristle. Wing 10.5 mm long, the costal and **S**-bands narrowly touching on vein R_{2+3}; proximal arm of **V**-band rather broadly joined to **S**-band anteriorly; distal arm slender, separated from proximal arm anteriorly; vein M_{1+2} but little turned forward at apex. *Female:* Body, exclusive of ovipositor sheath 9.5 mm long. Ovipositor sheath 8 mm long, slender. Ovipositor about 6.9 mm long, very slender, the shaft about 0.04 mm in diameter; the tip is figured by Costa Lima as being no wider than the shaft, without teeth or processes, but it is probable that the view is a lateral one.

Holotype.—Female (Instituto Oswaldo Cruz).

Type locality.—S. Gabriel, Rio Negro, Amazonas, Brazil.

Distribution.—Known only from the type specimen.

Remarks.—The above description is based upon the original description, since I have not seen the species.

9. **Lucumaphila zernyi** (Costa Lima), n. comb.

Dacus parallelus Wiedemann (part), Aussereuropaische zweiflugelige Insecten **2:** 515, 1830.

Anastrepha zernyi Costa Lima, Mem. Inst. Oswaldo Cruz **28:** 425, pl. 62 fig. 2–3, 1934; O Campo **8:** 38, 1937.

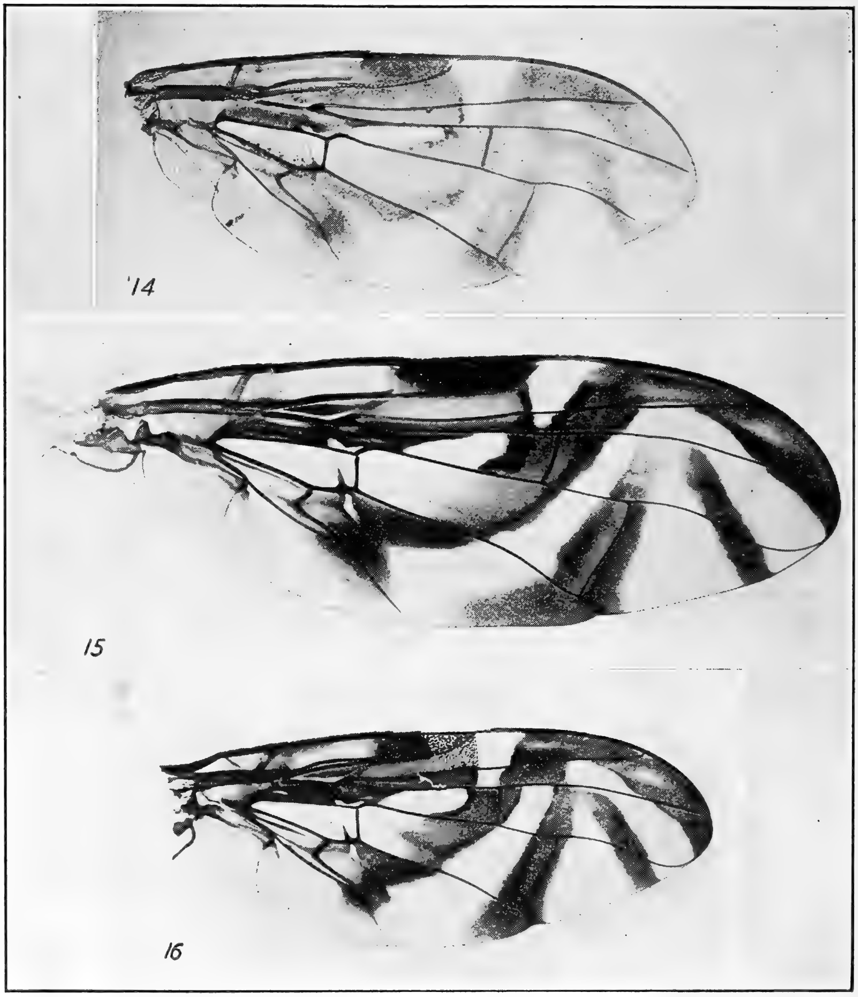

Fig. 14.—Wing of *Lucumaphila sagittata*, n. sp. Fig. 15.—Wing of *L. hamadryas* n. sp. Fig. 16.—Wing of *L. acidusa* (Walker) (photo by John Smart).

Rather large, yellow-brown. Mesonotum 3.9 mm. long. Thorax yellow-brown, a small brownish spot on mesoscutum just anterior to corner of scutellum. Macrochaetae orange-brown; pile yellowish brown. Sternopleural bristle slender. Wing 8.5 mm long, the bands yellow-brown; costal and **S**-bands narrowly touching; proximal arm of **V**-band rather broadly joined to **S**-band anteriorly. *Female:* Ovipositor sheath 4 mm long, slender, the spiracles 0.97 mm from base. Tip of ovipositor lost in the specimen before me.

Holotype.—Female (Naturhistorisches Museum, Vienna), cotype of *Dacus parallelus* Wiedemann.

Type locality.—Brazil.

Distribution.—Brazil.

Remarks.—Besides the type, this species is known only from a pair in the American Museum of Natural History, collected at Chapada, Brazil, which I believe belong to this species. The foregoing description is based upon these latter specimens. The species agrees very closely with *hamata* save for the distinctly shorter ovipositor. The male has lost most of its abdomen.

10. **Lucumaphila hamata** (Loew), n. comb.

Trypeta hamata Loew, Smithsonian Misc. Coll. No. 256: 229, pl. 11, fig. 22, 1873.

Anastrepha hamata (Loew), Bezzi, Boll. Lab. Zool. Gen. Agr. Portici **3**: 284, 1909.—Hendel, Abh. Ber. Zool. Anthr.-Ethn. Mus. Dresden **14**(3): 14, 1914.—Greene, Proc. Ent. Soc. Washington **36**: 157, pl. 2, fig. 3, 1934.—Costa Lima, Mem. Inst. Oswaldo Cruz **28**: 524; O Campo **8**: 38, 1937.

Large, yellow-brown. Mesonotum 4.5–4.8 mm long. Thorax yellow-brown, slightly darker just anterior to scutoscutellar suture; metanotum not or little darkened laterally. Macrochaetae orange-brown; pile yellowish brown. Sternopleural bristle very weak or absent. Wing (Fig. 13) 9.8–11.2 mm long; costal and **S**-bands joined for a short distance along vein R_{2+3}; proximal arm of **V**-band rather narrowly joined anteriorly to **S**-band; distal arm more or less reduced, often confined to a small streak near hind margin, but occasionally narrowly connected to proximal arm. *Female:* Ovipositor sheath 6–7.25 mm long, slender, the spiracles 1.22 to 1.44 mm from base. Ovipositor 5.2–6 mm long, very slender, the shaft about 0.026 mm in diameter, the tip slightly expanded, serrate as in Fig. 6. *Male:* Claspers stout, the apex blunt in lateral view; cephalic view as in Fig. 9.

Cotypes.—Male and female (location unknown).

Type locality.—Brazil.

Distribution.—Brazil and Panama.

Remarks.—The above description is based upon six specimens in the United States National Museum which appear to belong to this species. The data for these specimens are as follows: Brazil (Compere); Amazon River, Arary to Manaos, Brazil, September 20–21, 30 (Holt, Blake, and Agostini); Barro Colorado Island, Canal Zone, September 17, 1937 (Zetek); La Campana, Panama, November 1937 (Zetek); Balboa, Canal Zone, June 1938 (Zetek).

11. **Lucumaphila acidusa** (Walker), n. comb.

Trypeta acidusa Walker, List of the specimens of dipterous insects in the collection of the British Museum **4**: 1014, 1849.

Anastrepha acidusa (Walker), Aldrich, Smithsonian Misc. Coll. No. 1444: 602, 1905 (part).—Costa Lima, Mem. Inst. Oswaldo Cruz **28**: 530 and 604, 1934.

I have not positively recognized this species. The type has lost a portion of the ovipositor sheath and ovipositor so that the length of these and the character of the rasper are unknown. Dr. Smart has mounted the remnants of the ovipositor sheath and ovipositor and sent photographs to me. The shaft of the ovipositor is about 0.021 mm wide and this extreme slenderness combined with the general appearance makes assignment to this genus quite certain. The species would run to *hamata* in the key and seems to agree in every particular save that the **V**-band is complete, a condition unusual in *hamata.* Dr. Smart also photographed the wing of the type (Fig. 16). The pattern of the missing portion is indicated by stippling as it appears on the opposite wing.

Holotype.—Female (British Museum).

Type locality.—Jamaica.

Remarks.—It is to be hoped that the species can again be collected in Jamaica so that it can be more fully described. The name *Anastrepha acidusa* has been used a number of times for the species that Sein described as *A. mombinpraeoptans,* and the Florida record mentioned by Aldrich is probably this latter species. *A. mombinpraeoptans* has an unusually short ovipositor and in a number of other respects is quite different from the species described by Walker.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

GEOLOGICAL SOCIETY

566TH MEETING

The 566th meeting was held at the Cosmos Club, November 9, 1938, President H. D. Miser presiding.

Program: E. B. Eckel: *Abutment problems at Zuni dam, New Mexico.*—The Zuni dam is an outstanding example of the fact that no dam can be better than its natural foundations. It is built in a narrow gorge that has been cut through a 30-foot basalt flow and into underlying alluvium. A bed of loose sand lies between the base of the flow and a layer of tough clay. The abutments have caused trouble ever since the reservoir was first filled. The most serious difficulties occurred in 1909 and 1936, when large leaks broke out on the south abutment. Both resulted in cracking and settlement of the lava cap and loss of reservoir water. A cut-off wall, built after the first break, was effective for 27 years. The leaks were caused when water entered openings in the basalt and reached the sand layer. This layer acted like a broad, flat pipe and led the water to an outlet below the dam. The sand was flushed out, allowing the spillway and abutment to settle. After the 1936 break, a combination dike and blanket was laid along the south abutment in order to prevent entrance of water into the basalt. The new structure has been tested only for a short time but will apparently be effective. Several geologic problems involved in the repair work were discussed by the speaker.

C. P. Ross: *Some comments on the geology of quicksilver.*—Quicksilver deposits are widely distributed but so irregular and individually small that it is difficult to prospect for them or to block out ore in advance. Even more than other metals, they are deposited far from their original sources and in areas relatively free from commercial deposits of other metals. Most of the production has come from a small percentage of the known lodes. The deposits are localized where structural conditions furnish comparatively abundant openings in the rocks and where decrease in temperature and pressure and, at least in some places, mingling with acid groundwater, promote precipitation. In some places, concentration into deposits of commercial grade is assisted by structural traps.

J. S. WILLIAMS: *Lower Permian of the type area, U.S.S.R.*—Members of the Permian excursion of the Seventeenth International Geological Congress in the U.S.S.R., visited the typical region of the Permian system of Murchison and of the Artinskian, Kungurian, Ufimian, Kazanian, and Tartarian subdivisions. Murchison's original Permian included beds down to the base of Kungurian. He placed the Artinskian or Artinsk grits in the top of the Upper Carboniferous. Karpinsky described cephalopods from these grits from several localities, some of which (especially those from the Orenburg region about 350 miles south of Artinsk) he recognized were from beds that were of Artinskian facies but older than the beds at Artinsk. Later work has shown that in places beds of Artinskian facies go as far down as to the Lower Carboniferous. Tschernyshew, in 1904, published his work on the Upper Carboniferous brachiopods of the Urals and Timan. In this influential work he placed the top of the Upper Carboniferous immediately above his "*Schwagerina*" zone. Both Karpinsky and Tschernyshew considered the Artinskian as Permo-Carboniferous, as also did the Central Geological Committee.

The Permian is currently divided into a twofold division by geologists of the U.S.S.R. The Lower Permian in the type region now consists of an upper, Kungurian, subdivision and a lower, Artinskian, subdivision. The Upper Carboniferous has been generally known as the Uralian. Geologists differ regarding the horizon at which the boundary between the Uralian and the Artinskian should be placed and some would place a new division, the Sakmarian, between them. In the U.S.S.R., as in the United States, several boundaries between the Permian and Carboniferous each have adherents. Three boundaries have, however, the most adherents in the U.S.S.R. The highest of these is immediately below the zone commonly referred to as the *Pseudofusulina lutugini* zone, correlated with the Phosphoria and Word formations of the United States by some and with the Upper Leonard by others. The next highest boundary is immediately below the *P. anderssoni* zone, which is itself immediately below the *P. lutugini* zone. The *P. anderssoni* zone has been correlated with part or all of the Leonard formation of the United States. Below the *P. anderssoni* zone is the *P. moelleri* zone and below that zone is the well-known so-called "*Schwagerina*" (now *Pseudoschwagerina*) zone. These zones together probably comprise the Sakmarian, proposed by Rutzensev from studies in the Orenburg region. The lowest of the principally advocated boundaries is immediately below the so-called "*Schwagerina*" zone.

From publications the writer has read and from impressions gained in the U.S.S.R., he believes that the boundary below the *P. lutugini* zone is the most widely used in the U.S.S.R., but no statistical evidence was obtained. Reasons advanced by various Soviet geologists for placing the Permian-Carboniferous boundary here include the following: A bryozoan specialist would place it here because of a discontinuity in bryozoan development; a fusulinid specialist, because of a discontinuity in the sequence of fusulinids; and a coral specialist, because of the appearance of certain peculiar corals. Others cite changes in certain plants, the fact that a sharp change in lithology and an unconformity come at the base of the *P. lutugini* zone near Artinsk, and the presence of stratigraphic breaks at places on different continents approximately at this horizon.

Soviet geologists who would place the boundary immediately above the *P. moelleri* zone cite the following among their reasons for doing so: A fusulinid specialist believes the fusulinids below this boundary are more closely related to Upper Carboniferous than to younger fusulinids. This same geologist states that a sharp change in geographic and sedimentary conditions and diastrophic processes begins here, that it is very convenient to place the boundary here because of the ease with which underlying beds can be identified, and that Murchison's lower Artinskian boundary was above this zone. Another geologist would place it here because Tschernyshew, who has been widely followed both in official and other reports, placed the Upper Carboniferous boundary above the *Schwagerina* zone. Still another would place it here because of an unconformity above the "*Schwagerina*" zone.

Rutzensev and Nalivkin are the chief Soviet advocates of placing the boundary at the base of the so-called *Schwagerina* zone. They advocate this boundary because they believe that the ammonoids of this zone are more closely related to younger than to older rocks, because of a discontinuity in the sequence of fusulinids; because Karpinsky described as Artinskian certain cephalopods found in *Schwagerina*-bearing beds in the South Urals, which are of Artinskian facies (even though Karpinsky did recognize that these cephalopods were older than those of the Artinskian at Artinsk), and because certain coral genera which occur in undisputed Permian beds elsewhere occur in the *Schwagerina* beds. Another cephalopod specialist would place it here mainly because of discontinuities in the cephalopod development, and a Soviet coral specialist would also place it here. Other arguments were advanced chiefly by foreign geologists.

The number of boundaries advocated, each of which seems most logical if certain selected criteria are used or if the emphasis of a single criterion is favorably placed, suggests that an agreement on criteria to be used is the first step in the solution of the problem of the lower Permian boundary. Few would suggest holding strictly to priority, the most easily followed criterion. Lacking such an agreement also on other criteria, as at present, preponderance of the usage followed in the type region seems to promise as nearly a satisfactory standard as it is possible to obtain. Restriction of the standard to the type region would localize the problem in an area that could be studied in detail and would put the determination of period standards essentially on the basis that is generally used in interpreting disputed details about formations. If world-wide opinion should demand a change to some other sequence than that of the present type region as a standard because of the absence of intermediate beds in the type locality, which does not seem to be likely, or if world opinion should demand the use of some boundary other than that generally used in the type region, because of agreement upon a more satisfactory boundary the world over or for some other reason, recourse could then be had to a world-wide representative vote or to such an organization as the International Geological Congress, which has considered similar problems. It seems likely, however, that if world-wide opinion were decidedly against the boundary commonly used in the type region, it would force a change there without the necessity of action by an International Geological Congress.

As stated earlier, the original Permian of Murchison extended down to include the Kungurian. In the early part of this century, the Central Geological Committee placed the Kungurian and Artinskian in the Permo-Carboniferous. In 1917, they transferred these beds to the Permian. Tschernyshew's work has been most widely followed since its publication, but the use of his classification is hindered because part of his section is said to have been misinterpreted and because some maintain that "*Schwagerina*" is not a narrow-zone fossil as once thought but ranges through a considerable section in some places and occurs in beds that are of different ages in different places. It is the writer's distinct impression that most Permian stratigraphers in the U.S.S.R. now place the boundary above the "*Schwagerina*" zone as it is generally interpreted, and that it is so placed in most official publications of the Central Geological and Prospecting Institute.

Because there seems to be some indication that present opinion in the U.S.S.R. may change and because many geologists in the United States place the boundary below the "*Schwagerina*" zone, the writer continues to advocate, as he has since 1936, that some group name be selected for this zone, that this group be designated temporarily as Pennsylvanian or Permian, and that correlations be made mainly in terms of the group units with less emphasis being placed on the location of the Pennsylvanian-Permian boundary. The widespread use of such group units as reference points for correlations would restrict our problems mainly to areas in the United States that can be visited repeatedly and studied in detail. It would fully serve the needs of most geologists, because most geologists are interested mainly in local and perhaps sectional correlations. These are only confused if the details of international problems inherent by definition in the setting of period standards and the drawing of period lines are introduced into local controversies.

567TH MEETING

The 567th meeting was held at the Cosmos Club, November 23, 1938, President H. D. Miser presiding.

Informal communications.—Mr. J. B. Mertie described the Dufay and Kodachrome processes of making colored transparencies and projected a number of Dufay color photographs that he had taken in Alaska during the past field season.

Program: R. C. Cady: *Erosional history of the North Platte Valley in Nebraska.*—The North Platte River in the region of Scotts Bluff County, western Nebraska, has cut its valley over 1,000 feet below the upper level on the plains. Gravel occurs on the high level of the plain north of the river, and as the river eroded the valley the gravel was washed down the valley sides. This gravel cover protected the terrace surfaces from erosion and thus aided in their preservation. The upland plain south of the river furnished much less gravel than that to the north, with the result that the terrace surfaces on the south side were not preserved, and the south side of the valley is steeper than the north side.

Six terrace levels can be recognized, including the gravel remnants on the upland. The fifth level (numbered from lowest to highest) is a steep, convex slope covered with coarse gravel. It seems to represent the greatest part of the Pleistocene erosion. Four substages are suggested by breaks in slope on this surface, the lowest being a line of hillocks 300 feet or more above the level of the river. The fourth terrace level is a rock bench covered with gravel. The surface of the third terrace is 80 to 100 feet above the present level of the river. After its formation the river and tributary streams cut deep, narrow trenches into it. The river cut down about 300 feet, but the tributary gulches were not cut so deeply. Before they could be widened very much they were refilled with gravel. The bottom of the channel that was cut and refilled by the river now lies about 200 feet below the present level of the river. After the channels were refilled the river began to cut down again, and to widen its inner valley by lateral corrasion. It reached grade at a level 40 to 50 feet below the surface of the third terrace. The tributary streams also cut down but not so deeply as the river. Fine-grained sediments were deposited in the newly eroded valleys, partially filling them. The remnants of this fill constitute the second terrace. The river and tributary streams were again rejuvenated and they began to cut through this fill. Most of the remnants of the second terrace were removed from the valley of the river, but they are still preserved in some of the tributary valleys. After about 20 to 30 feet of downcutting had taken place the new gullies were again partially filled with fine-grained sediment. Remnants of this fill constitute the first terrace. Since that time the streams have cut about 15 or 20 feet below the top of the first terrace.

The terraces, particularly the third, second, and first, possess characteristics that render them recognizable in other valleys in the region.

Little is definitely known of the age of the terraces. Vertebrate fossils are being collected from gravels on the fifth terrace, and they are considered to be early Pleistocene in age. Yuma artifacts in association with extinct bison have been taken from sediments that constitute the second terrace. Hearths and pottery of not very ancient date are found in the sediments of the first terrace. The second and first terraces are more similar to each other than to any of the older terraces. Also, more erosion took place in the interval between the third and second terraces than took place between the formation of the second terrace and the first. It is believed, therefore, that the second terrace may be late Wisconsin or early Recent in age.

M. M. Knechtel: *Large boulders and glacial striae near Little Rocky Mountains, Mont.*—Extending southeastward for at least 36 miles from Snake Butte, a prominent feature of the plains of the Fort Belknap Indian Reservation north of the Little Rocky Mountains, Mont., is a train of glacial boulders, many of which are very large. The igneous rock composing the boulders is identical with that exposed on Snake Butte, and on top of the butte glacial striae elongated southeastward indicate that the boulders were transported by the glacier and not, as has been supposed, by icebergs floating in water ponded between the ice front and the high land at the base of the Bearpaw and Little Rocky Mountains. As there are reasons for believing that the Keewatin ice sheet advanced into the Montana plains from the northeast, deflection of the ice southeastward by the Bearpaws and Little Rockies is indicated.

J. T. Pardee: *Post-Tertiary faulting of intermontane basins, western Montana.*—The region considered is part of the physiographic province known as the Northern Rocky Mountains. The principal mountain group and ranges within it attain altitudes of 10,000 feet or more and rise 4,000 to 6,000 feet above adjacent lowlands. The mountains are maturely dissected by narrow, steep-sided valleys but flat or gently sloping surfaces of noteworthy extent remain on many of the summits. Between the different mountain groups and ranges are 40 or more wide intermontane basins that aggregate 10,000 square miles or about one-fourth of the total area.

The intermontane basins are underlain largely by Tertiary and later sediments that rest unconformably on a bedrock floor eroded across strongly deformed older rocks that also compose the mountains. The structure of the

Tertiary sediments suggests downwarping in some of the basins and downfaulting in others. The idea of downfaulting is supported by the occurrence of fault scarps at one side or the other of several of the basins. Among these are low scarps of Recent age in the Madison, Centennial, and Red Rock (Lima) Valleys that are formed in unconsolidated alluvium and glacial deposits. Others are more or less worn scarps in the older rocks that form certain mountain fronts. Some of these mark vertical displacements of as much as 5,000 or 6,000 feet. The two severe earthquakes recorded in this region within the past 15 years appear to have been caused by movements on faults, marked by the older scarps only belonging to a system along the eastern side of the mountain province.

568TH MEETING

The 568th meeting was held at the Cosmos Club, December 14, 1938, Presient H. D. MISER presiding.

The prize for the best paper presented to the Society during the year was awarded to Mr. K. J. MURATA. The second prize was awarded to Mr. R. E. STEVENS.

Program: Presidential address by H. D. MISER: *Our petroleum supply.*—The United States produces and consumes three-fifths of the world's annual output of petroleum and it possesses about half of the world's known reserves. Our domestic petroleum production is obtained from about 360,000 wells in 22 States, and its value is one-fourth the value of the entire annual mineral production of the United States.

Petroleum and its associated hydrocarbons have been used by the peoples of many lands for at least several thousand years; and the history of their recovery, transportation, treatment, and utilization records a fascinating story of the progress of human civilization. The phenomenal growth of the petroleum industry in the United States since 1859, when our first well was drilled for oil, has been greatly aided by geology. The number of geologists now serving the industry in the United States, in the employ of companies and in the employ of Governmental, State, and other institutions, appears to exceed 3,000. The oil geologist, in the search for petroleum, makes use of facts and conclusions from many phases of geology, including structure, stratigraphy, paleontology, sedimentary petrology, sedimentation, geomorphology, and metamorphism; and, because of the vast amount of information obtained from deep wells, as much as 15,004 feet in depth, and from the 30,000-foot depths reached by geophysical methods, he has made notable contributions to the general science of geology.

46TH ANNUAL MEETING

The 46th annual meeting of the Society was held immediately following the 568th regular meeting. The reports of the secretaries, the auditing committee, and the treasurer were read and approved.

The Society elected the following officers for the year 1939:

President: J. B. MERTIE, JR.
Vice Presidents: J. B. REESIDE and J. T. PARDEE
Treasurer: T. B. NOLAN
Secretary: P. D. TRASK
Members-at-Large-of-the-Council: A. A. BAKER, R. W. BROWN, T. A. HENDRICKS, E. A. TRAGER, J. S. WILLIAMS.

The Society also appointed Mr. HUGH D. MISER its nominee for vice-president of the Washington Academy of Sciences.

J. W. GREIG, *Secretary*

Obituary

The death of Willard Dell Bigelow on March 6, 1939, brought to its close the career of a distinguished pioneer in food research, whose passing is mourned by a great host of personal friends and scientific contemporaries the world over.

Dr. Bigelow was born at Gardner, Kansas, on March 31, 1866. He was graduated from Amherst in 1889, subsequently serving a short term as associate professor of chemistry at Oregon State College. This was followed by post-graduate work at Amherst, and in 1892 Dr. Bigelow accepted a position in the U. S. Bureau of Chemistry. In 1901 he was made chief of the Food Division of the Bureau of Chemistry, and in 1903 became assistant chief of the Bureau. Following enactment of the Federal Food and Drugs Act in 1906, he was associated with Dr. Harvey W. Wiley in the enforcement of the Act and had the primary responsibility for the selection of personnel of the new branch laboratories.

In 1913 he became associated, as chief chemist, with the newly organized research laboratories of the National Canners Association, and in 1918 he became the first director of the laboratories.

He was universally recognized as one of the leading authorities on foods and food legislation, and tribute was paid to his ability and learning by his election to many offices of distinction in scientific organizations and societies. He was for many years a director and counselor of the American Chemical Society, and he served as president of the Association of Official Agricultural Chemists and of the Association of Dairy and Food Officials.

Outstanding among his many services to the canning industry were his contributions to the study of the tin container, the nutritive value of canned foods, and the fundamental methods for establishing safe processes for all classes of canned foods.

Dr. Bigelow was respected by all for his wise counsel, upright character, and sound judgment; his kindliness and courtesy won the friendship and affection of those with whom he came in contact.

In 1901 he was married to Miss Nancy M. Nesbit, who, with their two daughters, Miss May Thorpe Bigelow and Mrs. Jessie B. Martin, survives him.

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This JOURNAL, the official organ of the Washington Academy of Sciences, publishes: (1) short original papers, written or communicated by members of the Academy; (2) proceedings and programs of meetings of the Academy and affiliated societies; (3) notes of events connected with the scientific life of Washington. The JOURNAL is issued monthly, on the fifteenth of each month. Volumes correspond to calendar years.

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CHEMISTRY.—*Some problems in attaining adequate nutrition.*[1]

Paul E. Howe, U. S. Bureau of Animal Industry.

In observing the problems that arise in the feeding of large groups of men in the Army and in charitable and penal institutions, and contrasting these problems with those that are encountered in the feeding of farm animals, I have been impressed with the extent to which man's aesthetic reactions to foods handicap his nutritional status. Much of the malnutrition that exists both inside and outside of institutions, as well as the unrest, discontent, and low morale that lead to demonstrations, riots, and other disciplinary problems, is the result of man's unwillingness or inability to base the satisfaction of his appetite on his dietary needs and on the restriction of his purse.

Nutritional workers have calculated the needs of both men and farm animals and have determined by analyses which of the available food products contain the essential elements in forms suitable for use.

In farm animals the nutritional problem is fairly simple. Scientific investigators have drawn definite conclusions as the result of laboratory work with animals and feeds and have made definite recommendations. Feeds for animals are evaluated scientifically on the basis of their nutritional and economic factors. On such a basis farmers are able to work out feeding schedules for their livestock in a sound and economical manner. It would seem equally feasible and highly desirable to approach human nutritional problems in the same objective manner.

Man, however, uses food as a means of satisfying many emotional needs, which are so closely tied up with his physiological needs that unless they too are met he fails to get the most from his food. He enjoys and even demands variety, not only in foods themselves but in methods of preparing them. He wants foods that appeal to his eyes and his senses of taste and smell; he wants to eat in pleasant surroundings. Traditionally, partaking of food with other persons has been of such social importance that the emotional satisfaction derived from eating has often overshadowed the actual physiological

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[1] Address of the retiring president of the Washington Academy of Sciences, delivered on January 19, 1939. Received July 8, 1939.

needs supplied by food. These factors greatly complicate the attainment of an adequate diet.

No really comprehensive treatment of nutrition is possible in the limited time available. Therefore, I have selected for discussion certain phases of human dietary habits and some of the possibilities and complications that arise in the practical application of our knowledge of foods and nutrition.

COMPLICATIONS IN HUMAN NUTRITION

Man's fundamental nutritive requirements, as determined experimentally, are usually expressed in terms of chemical compounds or complexes—proteins, fats, carbohydrates, etc.—of the foods commonly included in his diet. Until recently these compounds making up the major parts of the diet were the chief consideration. The importance of the vitamins and certain of the mineral elements required in small amounts is now being recognized. Some of these compounds are known only by the effects produced in the organism when they are absent from the diet.

The necessary quantities of the various foodstuffs vary with the size, age, and activity of the individual concerned and with the external conditions to which he is subjected.

The requirements for the various nutrients are seldom considered by man when arranging his diet. Instead, he thinks in terms of food—meat, potatoes, milk, salads. As the science of nutrition has progressed, it has been necessary to reevaluate foods as sources of the various nutrients and to indicate the uses of particular classes of foods in the diet. To make the best use of available foods in meeting the variety of tastes and habits in man, it is necessary to know the composition of foods, the variations in the composition of the same food, and changes that occur between harvesting and consumption. Furthermore, variations occur in the composition of different varieties of the same product and also as the result of maturity, climatic conditions, the fertility of the soil, and other factors.

The preservation and purification of foods add further complications. Natural foods contain some of almost all the necessary nutritive factors, although the quantities present may be so small that the food can not be considered an important source of that particular factor. The methods of preservation and purification used to keep foods from spoiling or losing quality or to make them more attractive often change the composition of the original food. Thus, there may be a reduction in certain constituents on drying or cooking, or a concentration of nutrients such as occurs in the manufacture of white flour, refined sugar, and polished rice. These changes create special nutritional problems when products of this type form the major part of a diet. The use of polished rice is a good example. In polishing rice the outer hull and the germ, which contain vitamin B_1, are removed, leaving the inner starch-rich endosperm. People who live largely on polished rice develop the nutritional deficiency disease known as beriberi. This can be corrected by feeding the rice polish itself or some other source of vitamin B_1. Once polished rice has been used it is very difficult to get people to accept unpolished or brown rice, in spite of its superior nutritive value. The use of refined products, however, is not objectionable in itself, but it necessitates careful selection of other foods if the diet is to be adequate.

To meet the various food habits and tastes of a cosmopolitan population it is important to popularize more than one source of each nutritive factor. Fluid milk, for example, is the standard source of calcium. The daily consumption of a quart of milk by a child or a pint by an adult is an assurance of an adequate calcium intake. But those who do not like or can not get fluid milk may substitute canned or dried milk, cheese, an extra amount of leafy vegetables, or even calcium salts and still meet their daily calcium requirements.

Carotene, one of the precursors of vitamin A, is chiefly responsible for the yellow color of vegetables and milk. Carotene is also present in the green leaves of plants, although masked by the green color. Any of the yellow or green vegetables, especially the leafy vegetables, or the yellow foods derived from animals, may be selected as a probable source of vitamin A.

An example of the value of substituting one food for another for economic reasons was shown some years ago by Dr. A. F. Hess. At a time when lime juice and lemon juice were the accepted sources of vitamin C, the antiscorbutic vitamin, Hess demonstrated the value of tomato and potato juice for treatment of scurvy in Negro children in New York. In this way he introduced antiscorbutic foods that were cheap and easily obtainable.

SIMPLIFYING SELECTION BY USE OF FOOD GROUPS

To simplify selection, foods that are somewhat similar in composition or are particularly valuable as a source of one or more nutrients may be grouped together. For example, meats, milk, and eggs are sources of protein of good quality; milk, the leafy vegetables, and dried legumes are sources of calcium; the green and yellow vegetables and butter fat are sources of vitamin A and carotene; fruits and vegetables, especially the acid products, are sources of ascorbic acid; and lean meat, milk, and the leafy vegetables are sources of nicotinic acid, the antipellagra vitamin.

By using such knowledge, it is possible to express the nutritive requirements in terms of the quantities of the various types of foods for an adequate diet. A classified dietary of this kind has been used rather successfully as the basis of dietary control in the Federal penal institutions. An example is given in Table 1.

TABLE 1.—STANDARD RATION FOR FEDERAL PENAL INSTITUTIONS
(Expressed in pounds per man per day)

Food groups	Type food	General messes	Hospital messes
Meats	Beef.	.75	.50
Fats	Oleomargarine.	.15	.15
Flour, etc. Spaghetti, macaroni, rice, etc.	Flour, white.	.80	.80
Dairy products	Milk, fresh.[1]	1.00	2.00
Eggs	Eggs.	.03	.25
Sugar and syrup	Sugar, granulated.	.25	.25
Beverages	Coffee.	.10	.10
Potatoes Roots	Potatoes.	1.00	.80
Leafy green and yellow vegetables (including tomatoes 0.10 lb.)	Cabbage.[2]	.60	.50
Beans, dried, etc.	Beans, navy.	.10	.10
Fruits, fresh or canned	Apples.[2]	.15	.25
Fruits, dried	Prunes.	.08	.08
Miscellaneous	Yeast.	.015	.015
Spices, etc.	Salt.	.10	.10

[1] In reporting evaporated milk, dried milk, and cheese, they are converted to their equivalents of fresh milk.

[2] When a greater quantity of some other food than the type food in this group is used in a given month, it becomes the type food for purposes of estimating the cost of the ration.

In this ration the foods are grouped according to one or more of the following characteristics: (1) Similarity of nutritive value, (2) palatability, and (3) dissatisfaction when too large quantities are used.

The use of food groups simplifies the recommendation of diets, offers considerable opportunity for variety of choice, and permits an approximate evaluation of diets from different parts of the country that reflect wide variations in food habits.

The monthly "Mess House Operations" report used by the United States Department of Justice for each Federal penal institution shows the total quantity and average daily consumption for each food group calculated to the pounds consumed per man per day. Other data related to the cost of the various items and waste are reported. A calculation is also made of the cost of such a ration based on the price paid for the type foods, reporting each food group as indicated in the preceding table.

A report of this kind is very useful in appraising the nutritional value of the food consumed and the economy of the expenditure for food in an institution. Such an analysis, combined with an examination of the menus, indicates the probable acceptability of the foods served, as well as the adequacy of the diet. A knowledge of the skill with which food is prepared and served in an institution is necessary for a complete understanding of the satisfaction derived from its operations. It is interesting to note that various institutions show individual food patterns characteristic of the region in which they are located. Furthermore, it is often possible to detect a change in stewards or in administrative control by shifts in the quantities of different foods used.

Reports of the kind just outlined should be as much a part of the records of all public institutions responsible for the care of men, women, or children as the financial reports. In fact, the justification for the expenditure of money in institutions, armies, or navies is to provide an adequate satisfactory diet. Without records of foods consumed, it is impossible to demonstrate the extent to which the expenditures have been properly made.

Dr. Hazel Stiebeling, of the Bureau of Home Economics of the United States Department of Agriculture, has successfully employed food groups in setting up dietary standards for persons of different ages and sexes at various levels of income or satisfaction.

USE OF THE MENU OR MEAL PLAN

When selecting or planning meals and reviewing dietaries, it is possible to use certain devices to test the adequacy of the diet or its probable acceptability, such as (1) by the quantities of each of the types or classes required, which has just been discussed, and (2) by a series of meal plans or menus. In reviewing dietaries, both kinds of information are needed if an indication of the probable acceptance of the diet is desired.

A menu may be considered as a plan by which foods are combined to make a satisfactory meal. By working out a series of menus a variety of foods and an adequate diet can be assured. Menus tend to follow patterns and are part of our food habits. Through the skillful planning of combinations of food, nutritive elements in which the diet was previously deficient may be added often without upsetting an accustomed routine. A large part of the success of this method of changing food habits lies in maintaining interest in the meals from day to day. This is just as true for maintaining good dietary habits as for changing poor ones.

Although the immediate concern will be with the proper nutritive elements in the menu, many other factors enter into the contentment and satisfaction people obtain from meals, particularly the methods of service and the surroundings in which food is eaten. Interest in food through the menu or meal plan is attained by (1) the use of foods attractive in themselves, (2) changes in methods of preparation of foods, and (3) combinations of the foods into attractively prepared dishes. In the last-mentioned case the attractive characteristics of some foods, such as meats, sugars, etc., may be used to add interest to less attractive but necessary or useful foods such as the bland cereal grains or vegetables.

It is not enough to provide variety among the meals of one day. It is necessary also to prevent the monotony that follows the frequent repetition of foods or combination of foods, or the repetition of the same foods at regular intervals. This is evident from the difficulties that arise in feeding large groups of persons such as in college dining halls, army messes, and correctional institutions, particularly when the cooking is mediocre. Poor cooking and monotonous meals have been responsible for many riots. It is a matter of record that Harvard College was almost wrecked in its early days because of monotonous and inadequate meals.

The meal plan offers a very useful method of selecting a meal from a restaurant menu or cafeteria counter. For example, in selecting a dinner one might soliloquize as follows:

"Soup? A small portion, it's appetizing and not too filling.

"Meat? Yes, a steak—no animal protein so far today.

"Potatoes? Yes.

"Other vegetables? Broccoli, turnips, beets, or carrots? Make it broccoli and carrots, not enough vitamin A so far.

"Salad? Lettuce or fruit? Lettuce with Roquefort dressing—more carotene and more calcium.

"Dessert? Cottage pudding? No, calcium is still low, make it pumpkin pie, and a cup of coffee.

"Now, let's see, I had grapefruit this morning, tomato juice this noon, and broccoli, carrots, butter, and salad tonight to provide sufficient vitamins C and A. The meat, bread, my peanut-butter sandwich this noon, and cheese provide plenty of protein. The calcium may be a little low but the cheese and pumpkin pie have helped, and there was skim milk in the bread.

"The B factors? I have had only white bread, but there were meat, peanut butter, cheese, and vegetables to help out.

"There is plenty of iron, and by the time I fill up on bread and butter there will be enough calories."

The chances are, however, that someone else plans the meals that you eat and enjoy without questioning whether all the necessary nutrients have been supplied. Even the housewife may use ready-prepared menus. What training did the person who planned the meals have? How well was the planning done? If a pattern was followed, was the pattern good? Upon the housewife, dietitian, cook, or steward often rests the responsibility for inducing us to eat foods that are needed even though we may not like them. They should be trained at least in the general facts of nutrition and the possibilities of changing food habits. We look to them to plan meals that we can enjoy with the assurance that they are adequate as well as appetizing.

Although menus and meal plans are useful in attaining a good diet, they alone do not provide sufficient evidence by which to judge adequacy. Often diets appear inadequate when judged by the menus but are shown to be adequate by analyses of the quantities of foods consumed. Conversely, a similar analysis of interesting-looking menus may show an insufficient intake of important foods, especially vegetables.

PSYCHOLOGICAL RESPONSES INFLUENCING ACCEPTANCE OF FOODS

I have so far discussed food requirements and methods of checking the adequacy of diets and have touched only lightly upon attitudes toward food and the difficulties that sometimes interfere with the attainment of an adequate diet. Although there are complications, they arise because of man's intelligence. In modern civilization many people have gradually conditioned themselves to expect and even demand a much more complicated dietary than is needed to satisfy nutritional needs. This enjoyment is one of the privileges of man. Insofar as people can afford these habits, they should enjoy them. Enjoyment is, however, only relative. New opportunities arise and with them new desires are created. On the other hand, when enjoyment interferes with the acceptance of an adequate dietary, the individual is faced with the dilemma of continuing his habits or accepting something that appears to him to be less interesting and satisfying. These changes are more easily accepted by the individual than by groups of individuals.

Man likes what he is used to, but he also likes a change. On this premise it should be possible, under circumstances in which he is faced with the need for a correction in the dietary, to condition himself to a new set of habits.

In any attempt to improve the nutritional status of a person, therefore, use should be made of instincts, appetites, habits, and any other devices to condition him favorably to desirable food habits. Hunger and appetite can be made valuable aids in securing the acceptance of food. Hunger that is due to actual contractions of the stomach stimulates the seeking of food. Appetite, on the other hand, is associated with the presence, or even the memory, of pleasant odors and flavors of food and may occur when the stomach is full. When hunger contractions or pangs occur, people show irritability and restlessness, even when the attention is so occupied that the contractions are not recognized. When three meals a day are eaten at regular hours, hunger contractions are seldom noticed, and when only one or two meals a day are eaten a certain amount of indifference to them may be built up. Excitement, pain, or anger inhibits hunger; outdoor exercise, physical work, or insufficient food stimulates hunger and lowers the level of discrimination, thus creating a situation favorable to the acceptance of new foods, that may be utilized when there is need to change dietary habits.

As a matter of fact, people often take food as the result of appetite rather than of hunger. Appetite stimulates the flow of digestive juices but is not essential to the digestion of food, since once in the stomach, food is equally well digested whether liked or not, provided no serious or continuous emotional factors are involved.

Habit plays an important role in the acceptance, as well as refusal, of certain foods and is thus useful in efforts to provide an adequate dietary. Habits are paradoxes. A man will eat the same breakfast year in and year out but will rebel if his dinners or suppers are the same or even if they are repeated at weekly intervals. In New England hot baked beans are traditionally necessary for Saturday suppers and cold baked beans for Sunday breakfasts. In the South boiled beans are or were often a customary second dish for both dinner and supper, but in other parts of the country if beans are served two meals in succession there is likely to be trouble.

Man is not alone in the persistence of habit in the face of change. Animals accustomed to a particular ration do not readily change to another unfamiliar diet. For instance, a farmer in Ohio purchased some cattle raised in North Dakota that had never been fed corn, and it took some time to teach these cattle to eat corn. He reports that one steer never did acquire the habit of eating corn. Animals, however, show a greater willingness to consume the food presented to them than does man. They can also be taught to expect variety in their diets. These habits usually result from the tutelage of man and are frequently seen in household pets, where their owners have projected their own conceptions of the pet's desire for variety or for particular foods.

Conditioning is another device that can be used to modify food habits. The classic experiment of Pavlov's dogs has led us to see how many of our actions, including attitudes toward food, are the result of conditioning or involuntary reactions to stimuli. Poffenberger favorably conditioned a group of students to music they did not like by playing it while they ate attractive meals. Most of us can explain an intense aversion to a particular food by its association with some painful event, or remember discovering that we "liked" a new food when it was eaten on a gala occasion. Conscious use of such methods of modifying established habits or creating acceptance of desirable foods offers a valuable means of improving dietary habits.

The role of instinct in determining the choice of foods is not certain, but some interesting examples of its effect on choice are reported. The new-born animal, born with a strong sucking instinct, having once found the nipple, soon learns to return to it with unerring accuracy. As it grows older it samples the various objects within its reach, learns that some foods are better than others, and builds up a standard of selection within the limits of food available.

An experiment with rats, conducted for the purpose of determining whether animals search for specific nutrients, indicated that the choice of a particular food was the result of a generalized search for food and that habit or conditioning played a part in its selection. Under experimental conditions rats have been found to choose a satisfactory diet from 11 relatively pure foods, including protein, carbohydrates, fat, certain vitamin-rich foods, and minerals, and to increase the consumption of sodium chloride or calcium where additional quantities of these elements were needed. Experiments with chicks showed that some of them consistently chose better diets than others.

Man's instinct or ability to select a satisfactory diet from among a number of foods or to modify the diet to meet changes in nutritive requirements has also been demonstrated. There is a careful report of three young children who were allowed complete freedom of choice from among a wide variety of natural foods over a long period of time. The diets selected met all their nutritive requirements and resulted in excellent growth. Normally, however, man's instinct is so overlaid by conditioning that he can not be trusted to select food with any relation to his physiological needs.

At present, sufficient evidence to determine the exact manner in which the body recognizes nutritional deficiencies and determines the choice of food is lacking. One suggestion is that nutritional deficits cause physiological changes in the body and that these changes alter the taste mechanism and set up a craving for a specific food.

These nutritional facts and the attitudes of man to food may well serve as the basis for considering a problem that frequently defeats efforts to improve the nutritional status by setting up dietary standards. A survey of dietary habits indicates that there is still much to be done in bringing people to accept a diet that meets the caloric needs of the body and provides a liberal allowance of all the nutrients required. It is concerned with the maintenance of morale in men fed in groups, as in the Army and Navy, and the practical application of the newer knowledge of nutrition to the improvement of our national health and economic welfare. The difficulties involved become evident when an attempt is made to change the food habits of persons satisfied with a generous but nutritionally inadequate diet, to make drastic changes in the food of troops and yet maintain their morale, to set up a restricted though adequate diet for persons on relief, or even to understand the problems of the housewife who tries to stay within her food budget and still have a well-nourished and satisfied family. In each case the major problem lies in getting the persons concerned to accept the foods that should be used among those that are available.

Evidence has just been presented that indicates that young children and animals will select a fairly adequate diet if given a reasonable variety of natural foods from which to choose, or that they will seek other foods if the diet presented is inadequate. But as man grows older and develops fixed habits this faculty of selection of the diet is apparently submerged and seldom used. The desire for palatable or customary foods displaces the urge to search for foods that will make the diet more satisfactory from a nutritional standpoint.

VALUE OF EDUCATION AND TRAINING

The most promising solution of the problem of getting people to accept an available adequate diet lies in education and training. Training must begin with the establishment of good food habits in the child and involves learning to enjoy a simple adequate diet and to be willing to accept new foods to replace or supplement customary foods. The success of this program depends largely upon skill and attitude of the mother. Although education begins at home, it should be carried on also in the schools. Information given there reaches back into the home and affects the parents and other members of the family. Finally, there are great possibilities for general education for better dietary habits, particularly for adults. Here the problem is to insure the sound, broad presentation of facts, unbiased and in their proper relationships. Many books, bulletins, and pamphlets containing a large amount of information about nutrition are available for use in the home and school. Radio broadcasts and household publications offer advice and aid in planning meals. Many of these are biased; hence the information should be carefully evaluated before it is accepted. Great care must be taken to make sure that material to be used in the schools is factually accurate, that it presents completely unbiased discussions, and that it promotes no food product exclusively. Sometimes material is offered as educational that is really special pleading for particular food products. It may be well written, accurate, and informative. While manufacturers and industries are justified in advertising the merits of their products, this promotional material usually lacks the detachment and broad approach that should characterize educational material and should not be confused with it.

A considerable part of current popular material about food is presented in the form of recipes. This kind of material is very useful in securing the acceptance of new foods or the wider use of common foods. While recipes may be of little immediate interest to students of nutrition they are of real value to those who must prepare and serve meals. Since these persons should always consider foods in relation to their nutritive values and their place in the diet, material on preparation should present facts about the place of the foods in the dietary. An example of an excellent service of this kind is the weekly mimeographed press release called "The Market Basket," which the Department of Agriculture has issued for a long time. It has combined information on the general nutritive requirements of the family with information on seasonable foods and presents simple yet attractive methods of preparation.

As previously pointed out, material that is to be used as a guide either in teaching nutrition or in planning dietaries should suggest more than one major source of each of the nutrients. This is especially true if the material is to be used by people in all parts of the country and if people are to be taught the possibilities of varied diets.

The average person can hardly expect to keep well informed about all the changes in and additions to knowledge of man's food requirements, but he should realize the extent to which his food habits play a part in determining his well being. He should also realize that these are not infallible guides and that a nutritionally abundant and reasonably satisfactory diet can be achieved at different income levels if one is willing to bring an open mind to its acceptance. If the housewife, steward, or cook can combine this knowledge with skill in the selection and preparation of food, real progress toward better nutrition can be made. Thus man can satisfy his body requirements for food without losing the opportunities to enjoy it.

BIOPHYSICS.—*Delayed killing of maize seeds x-rayed at liquid-air temperature.*[1]

Louis R. Maxwell, U. S. Bureau of Agricultural Chemistry and Engineering, and J. H. Kempten, U. S. Bureau of Plant Industry.

The first stage in the biological response to x-rays is the absorption of quanta with the production of high-energy primary electrons. As these particles traverse the medium they lose their energy in the process of ion pair formation. On the average as each ion pair is formed there will be about 32 electron volts of energy taken from the primary electron. These early physical phenomena will be independent of temperature changes and will always provide discrete amounts of energy to the medium. The ion pairs formed will react with neighboring molecules and, since their energy is large compared with ordinary thermal reactions, these processes should not be dependent on temperature. These ionic reactions will then provide the initial energies of activation for subsequent low-energy, including thermal, reactions. The subsequent changes will be manifested by changes in the living plant. It is to be expected that many of these low-energy reactions will depend upon temperature changes. Any external influences, such as extreme variations of temperature, that will greatly affect any of these fundamental steps should prove to be a useful tool in the investigation of biological response to radiation with x-rays.

Maintaining the specimens at about −187°C. by means of liquid air during irradiation should largely eliminate significant thermal reactions within the material. The subsequent development of such specimens under normal growing conditions should give information as to the actual importance of thermal reactions during the time of irradiation. In the present experiments dry maize seeds were used because they are able to withstand submergence in liquid air without seriously altering their subsequent growth (9).[2]

Various experimenters have investigated the effects of small changes of temperature during the time of irradiation by x-rays. Early work

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[1] Received May 24, 1939.

[2] Numbers in parentheses refer to the "Literature Cited."

by Muller (8) on *Drosophila melanogaster* and Stadler (10) on barley and maize showed no influence of temperature during irradiation on the observed mutation rates. As regards physiological changes (1) the temperatures used during irradiation have in general produced either no effect or else an increase in the amount of injury resulting from the irradiation as the temperature was raised. The literature on the genetic effect of x-rays has been summarized recently by Timoféeff-Ressovsky (12) and for plant cytogenetics by Goodspeed and Uber (5).

Crabtree (3) and Crabtree and Cramer (4) have shown that cold treatment renders cells more sensitive to radium radiation. This result has been confirmed by Mottram (7), who has shown that the growth of bean roots held at 0°C. during irradiation is much more adversely affected than when they are irradiated at 24°C. Apparently the temperatures used have not been below 0°C.

It has been found that under normal conditions maize seeds will respond to x-ray treatment in a very definite manner, which has been called "delayed killing" (2). An x-ray dosage of 70,000 *r* units for dry maize seeds will result, after normal germination, in complete delayed death as characterized by cessation of growth before the first leaf is fully exserted from the coleoptile. This type of response is obtained with certainty, and it was used in the present work as a criterion for detecting possible new developments arising from the use of liquid-air temperature.

EXPERIMENTAL PROCEDURE AND RESULTS

The experimental arrangement used is illustrated in Fig. 1. Directly beneath the x-ray tube was placed a large liquid-air flask in which a metal boat containing the maize seeds floated on the liquid air. The actual temperature was measured by means of a thermocouple embedded in one of the seeds, which showed that the seed temperature was not more than 2°C. above the temperature of the liquid air used (approximately -187°C.). Runs were made at room temperature under conditions identical with the liquid-air experiments by replacing the liquid air with water. This ensured that all secondary effects such as back scattering would be the same in both cases. After the x-ray exposures the seeds were brought up to room temperature within a few minutes.

A Coolidge air-cooled x-ray tube with tungsten anode was used at a constant potential of 45 k.v. This provided a continuous band of radiation with maximum intensity at approximately 0.50 Å. A sheet of black paper was used as a filter to eliminate heat radiation. The anode distance was 23 cm, exposure time $5\frac{1}{2}$ hours for 70,000 *r* units, and plate current 7 ma. Dosage values given were measured by means of a standard open-air ionization chamber (11) before and after each run. Dosage values given are accurate to within 5 percent.

Three treatments were given as follows: (*a*) 70,000 *r* units at liquid-air temperature, (*b*) 70,000 *r* units at room temperature, and (*c*) no x-ray exposure but cold treatment at liquid-air temperature identical to (*a*). To this group was added a fourth lot as controls, which were kept at room temperature and were not irradiated.

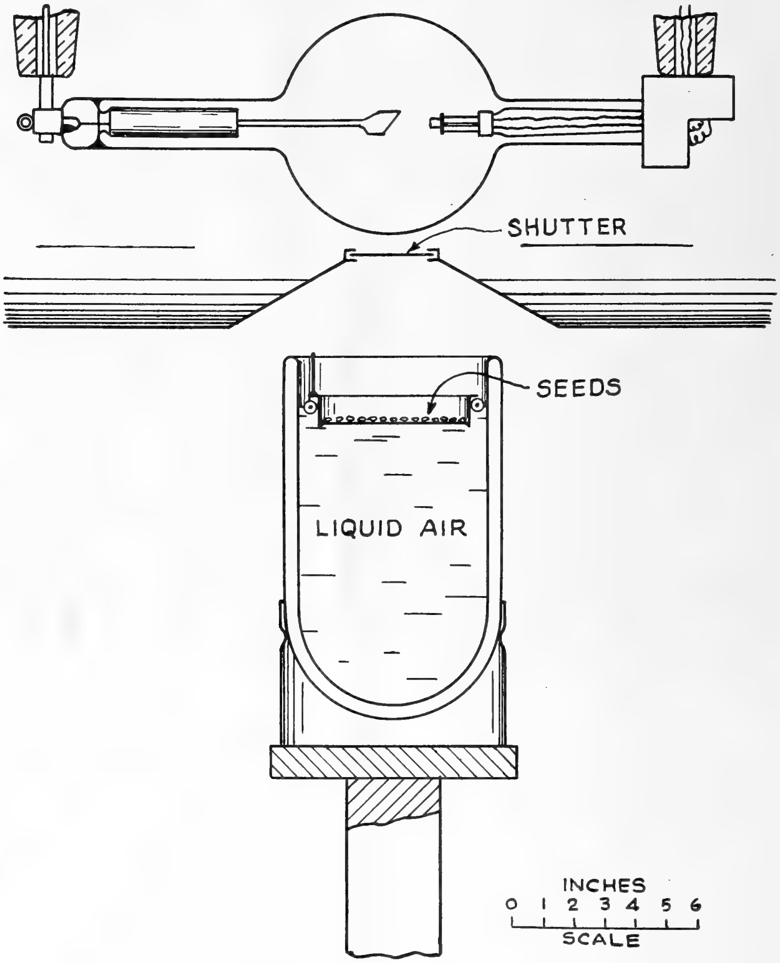

Fig. 1.—Diagram of the arrangement used in x-raying dry maize seeds at liquid-air temperature.

In each of the treatments 300 seeds of Funk Yellow Dent maize were used. This seed was drawn from a thoroughly mixed commercial stock that on testing had 8 percent moisture. This variety of maize has been used for several years in both x-ray and other radiation experiments and furnished the material on which the previous x-ray reports were based (2, 6). Experiments planned to disclose differential reactions of diverse types of maize to x-rays have been tried with negative results. It is believed, therefore, that the reactions obtained in the present experiment are general for maize seeds having no more than 8 percent moisture.

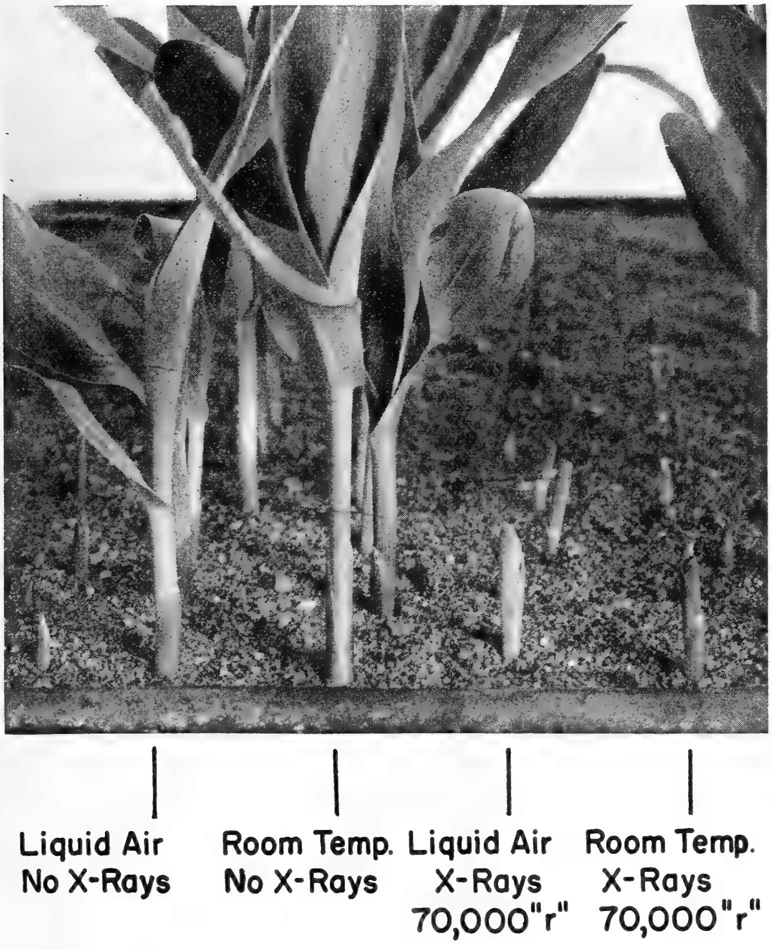

Fig. 2.—Section of a seedling flat showing seedlings natural size from the four classes of treated seeds.

The three lots of treated seeds, together with the controls, were planted in the greenhouse in seven metal flats within a few days after irradiation. These flats, 1 foot square and 4 inches deep, were designed to grow 12 rows of 12 plants each. The flats were filled to within one-half inch of the top with carefully mixed sterilized soil. After the seeds were planted points down and the crowns flush with the soil surface, the flats were filled level with the sides with water-washed sand. Thirty-six seeds from each treatment and the untreated control were planted in each of seven flats. With perfect germination this planting would provide 252 seedlings of each treatment. The position of the treatments within the four row blocks was random within each flat, and the flats were mounted on a compound clinostat where not only the table rotated but each flat rotated independently, thus eliminating between flats, and parts of flats, the effects of fixed shadows inevitable in greenhouse plantings.

Ten days after planting the heights of the seedlings were recorded in millimeters, the measurements being made from the box edges, not the soil surface. The plants were grown for another ten days to make certain there were no recoveries.

The results obtained show first that *delayed killing still occurs for the seeds held at liquid-air temperature during the time of irradiation,* as shown in Table 1 and illustrated in Fig. 2. However, within the x-rayed group the plants from seeds subjected to liquid-air temperature average 27 percent larger than those x-rayed at room temperature. The reverse of this is true for the plants from non-x-rayed seeds. In this latter case the plants from seeds cooled for 5½ hours at liquid-air temperature were 41 percent shorter than the controls. The difference in both cases is statistically significant as shown in the analysis of variance given in Table 2.

STATISTICAL TREATMENT OF RESULTS

Despite the precautions taken to ensure uniformity, the four row blocks differed among themselves more than would be expected from random variations. The variance of four row blocks was further subdivided into that contributed by differences between flats and that between the blocks within the flats. The ratios of the mean squares to the error mean squares show that the significant variability is between flats and not between the four row blocks within the flats.

The generalized error obtained from the entire experiment can not rightly be applied to the differences within x-ray treatments, because of the great disparity in size between the seedlings from x-rayed as compared with those from non-x-rayed seeds. However, the mean square for interaction shows conclusively that temperature and x-ray treatment had a significant combined effect. To derive generalized errors for the x-rayed and non-x-rayed seeds the two populations were considered separately. Analyzing the variance for the group of seedlings from x-rayed seeds we see that the temperature at which the seeds are treated produces a significant effect and similarly within the non-x-rayed group temperature produces a significant effect. For the size populations under consideration the error of the difference between the two temperatures within the x-rayed group is 0.45 mm and in the group of seedlings from the non-x-rayed group it is 1.84 mm.

TABLE 1.—NUMBER AND MEAN HEIGHTS OF MAIZE SEEDLINGS SUBJECTED TO THE INDICATED TREATMENTS

Treatment	Number of plants	Mean height
		mm
70,000 *r*, liquid-air temperature	226	10.12 ±0.30[1]
70,000 *r*, room temperature	239	7.97 ±0.30
No x-ray, liquid-air temperature	240	77.35 ±1.31[2]
No x-ray, room temperature	248	109.52 ±1.29

[1] Error of the difference between the x-rayed groups = 0.45 mm.
[2] Error of the difference between the non-x-rayed groups = 1.84 mm.

TABLE 2.—ANALYSIS OF VARIANCE

Treatment	Complete experiment[1]		X-rayed seeds only[2]		Non-x-rayed seeds only[2]	
	Degrees of freedom	Mean square	Degrees of freedom	Mean square	Degrees of freedom	Mean square
Total	83	1,976.7	464	25.0	487	716.4
Four-row blocks	20	61.2				
Two-row blocks			20	33.0	20	1,508.8
Treatments	3	53,468.1	1	536.2	1	126,257.9
Error	60	40.7	443	23.5	466	413.0
Subdividing blocks:						
Flats	6	134.4	6	19.2	6	3,546.9
Within flats	14	29.8	14	38.9	14	635.3
Subdividing treatments:						
Temperature	1	4,680.1				
X-ray	1	149,607.4				
Interaction	1	6,116.7				

[1] Based on means of rows to avoid unequal frequencies.
[2] Based on individual plants.

DISCUSSION

It can be concluded first that delayed death does not result primarily from temperature-dependent thermochemical reactions, which might take place during the time of irradiation. However, when the seeds are x-rayed at liquid-air temperature the extent of plant growth before death is greater than when they are irradiated at room temperature (approximately 21°C.). This would indicate that important destructive reactions that are involved in the phenomenon of delayed death can be retarded by holding the specimens at the temperature of liquid air during irradiation.

SUMMARY

1. The biological effect of x-rays is classified into essentially three stages:

   (a) Absorption of quanta with liberation of primary electrons and subsequent ion-pair formation.
   (b) Ion-pair reactions with the surrounding medium which are expected to be temperature independent involving chemical reactions which may require both low and high energies of activation.
   (c) All subsequent low-energy, including thermal, reactions affecting the life of the material.

2. Maintaining seeds at liquid-air temperature during irradiation should greatly reduce the number of thermal reactions occurring at time of irradiation.

3. Delayed killing of maize seeds by x-rays is found to occur for a dosage of 70,000 *r* units when they are irradiated at liquid-air temperature (about −187°C.). Extent of growth of delayed killed plants at liquid-air temperature is significantly greater than for seeds irradiated at room temperature.

4. It is concluded that delayed killing of maize is not due primarily to temperature-dependent thermochemical reactions that might take place during time of irradiation. Factors producing delayed death are diminished by using liquid-air temperature during irradiation.

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BOTANY.—*A second United States species of* Bernardia.[1] C. V. MORTON, U. S. National Museum.

All the United States plants of the genus *Bernardia* (Euphorbiaceae) have been referred to a single species, *B. myricifolia* (Scheele) Wats., described from Texas on material collected by Lindheimer. Specimens collected in Arizona and California have, however, a somewhat different appearance, and a detailed examination has proved that they represent a distinct species. The western specimens have small leaves (rarely over 1.5 cm long) of an ashy color due to the very close, stellate pubescence, the individual hairs being so minute (hardly over 0.1 mm long) that they can be seen only with a rather high magnification. The under side of the leaves is so densely covered that none of the leaf surface itself is visible. On the other hand, the specimen of the type collection of *B. myricifolia* in the U. S. National Herbarium and all the numerous other Texas specimens have relatively larger leaves (often 4 or 5 cm long) and a longer and less dense pubescence, perhaps best described as stellate-hirsutulous. The rays of the hairs are 0.5 to 1 mm long, and the leaf surface is frequently visible. The stipules of the western plant are relatively conspicuous, owing to their blackish-purple color; those of *B. myricifolia* are inconspicuous, pale green or yellowish in color.

The stamens of the western plant are either 5 or 6 in number (or sometimes 7 according to Jepson), those of *B. myricifolia* twice as many (11 to 15). It is possible that there may also be a difference in the color of the connectives, those of *B. myricifolia* being dark purplish, those of the western plant apparently yellowish and of the same color as the anther cells. A further difference is observable in the styles, which are 3 in number, each once-parted. In *B. myricifolia* the lobes are conspicuously and complexly laciniate, but in the western specimens they are frequently quite entire or bear only one or two teeth on each side.

The western plant, here described as *Bernardia incana,* is quite common in Arizona but apparently rare in California. Its range does not overlap that of *B. myricifolia,* which in the United States is found only in Texas and New Mexico. In Mexico the ranges of the two are equally distinct, *B. myricifolia* being found in eastern Mexico (Coahuila and Tamaulipas), *B. incana* only in Lower California.

The only other species of this relationship that has ever been de-

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[1] Published by permission of the Secretary of the Smithsonian Institution. Received May 4, 1939.

scribed is *Bernardia viridis* Millsp. from Lower California, the type of which has very kindly been lent by the University of California. This species was reduced to the synonymy of *B. myricifolia* by Standley, but it is evidently distinct. The material is inadequate for a complete diagnosis, but the relationship is decidedly with *B. myricifolia* rather than with *B. incana.*

It should be mentioned that both Jepson and Munz state that *B. myricifolia* (i.e., *B. incana*) is monoecious. I have examined a good many specimens carefully with this in mind but have never found both sexes on the same specimen, although both are often on the same herbarium sheet.

Bernardia incana Morton, sp. nov.

Frutex dioicus; folia alterna bistipulata, stipulis crassis cucullatis atropurpureis persistentibus; lamina foliorum oblonga, 10–15 (raro 25) mm longa, crenata, subtus cinerea, dense incano-puberula, pilis stellatis minutis pluriradiatis; pedicelli masculi graciles, sepalis 3 minutis, externe minute puberulis; stamina 5–7, antheris flavis, connectivo concolore; flores feminei solitarii vel bini, sessiles, segmentis 5 imbricatis, externe minute puberulis; styli 3 bipartiti, lobis integris vel dentes 1 vel 2 utroque latere gerentibus.

A much-branched, thorny, dioecious shrub, the stems terete, glabrate except at apex; leaves alternate, congested at the tips of short lateral branchlets, bistipulate, the stipules elongate-triangular, 1 mm long or less, cucullate, thick, blackish purple, externally puberulous, persistent; petioles short, terete, up to 4 mm long, about 0.5 mm in diameter, densely short-puberulous; leaf blades oblong, up to 25 mm long and 12 mm wide, rounded at apex, obtuse at base, regularly crenate, the crenations 4–6 on each side, subcoriaceous, subtrinerved at base, pale green above, cinereous beneath, densely short incano-puberulous beneath, the hairs stellate with many (about 10) rays, these not over 0.13 mm long, about 10μ wide; staminate inflorescence up to 15 mm long, axillary, the rhachis slender, densely puberulous, the bracts 4–6, minute, each subtending a fascicle of 3 or 4 flowers, the pedicels 2–2.5 mm long, very slender, often nearly glabrous; staminate perianth of three sepals, these free, ovate, about 1 mm long, valvate, acutish, pale yellow, externally puberulous; stamens 5 or 6 (or rarely 7), the filaments about 0.5 mm long, glabrous, the anthers yellow, suborbicular, about 0.25 mm long, the connective pale; rudimentary ovary none; pistillate flowers solitary or in pairs, sessile, the perianth segments 5, about 2 mm long, imbricate, the innermost linear; disk low, trigonal; ovary stellate-puberulous; styles 3, two-cleft, the branches simple or with 1 or 2 short lobes on either side; capsule about 6 mm high, 9 mm wide, densely cinereous-puberulous, the hairs stellate, similar to those of the lower leaf surface; seeds subglobose, pale brown, about 6 mm long, ecarunculate.

Type in the U. S. National Herbarium, no. 59822, collected at Sierra Tucson, Ariz., April 21, 1884, by C. G. Pringle.

ADDITIONAL SPECIMENS EXAMINED:

Arizona: Fish Creek, *McKelvey* 1110; *Peebles, Harrison, & Kearney* 5348. Sierra Estrella, *Peebles, Harrison, & Kearney* 3292. Superstition Mountain, *Gillespie* 8606. Lowell, *Parish* s. n. Bright Angel Trail, Grand Canyon, *Leiberg* 5953; *Goldman* 2225; *Coville* 1690, 1695; *Eastwood* 1. Pipe Creek, Grand Canyon, *Goldman* 2246. Congress Junction, *M. E. Jones* s. n.

California: Whitewater, *Parish* 752. Without special locality, *Parry & Lemmon* 375.

Lower California: San Pablo, *Purpus* 27.

PALEOBOTANY.—*A* Meliosma *in the Wilcox Eocene.*[1] EDWARD W. BERRY, Johns Hopkins University.

Many years ago Professor Newberry described a leaf that he christened *Viburnum cuneatum*[2] from the Eocene of Tongue River in Montana. This was ultimately figured in his posthumous monograph.[3] Newberry was very uncertain about this generic reference, and, as the specimen had none of the features of *Viburnum,* when I found what appeared to be identical forms in the Holly Springs sand of western Tennessee I reviewed a large amount of recent material and came to the conclusion that its affinities were with the Hamamelidaceae and transferred it to the genus *Parrotia* of that family.[4] Some years later better material was collected in Arkansas.[5]

I have been on the lookout for comparable recent material ever since and some years ago concluded that my earlier comparison with *Parrotia* was a mistake and that what it really represented was a species of *Meliosma.*

The genus *Meliosma* of Blume comprises more than half the existing species of the family Sabiaceae, which is hence a relatively small family, tropical or subtropical in its occurrence, mostly north of the Equator, and Asiatic and American. *Meliosma* is divided into two sections, the one with pinnate and the other with simple leaves.

The general features that distinguish these leaves is their obovate form; rather shiny firm texture; variable margin, either entire or when toothed generally entire in the lower half, when toothed rather irregularly so both as to spacing and emphasis; prominent primary venation; secondaries in the toothed forms indifferently craspedodrome or camptodrome, some ending in the teeth and others sending a tertiary branch into the teeth; tertiaries sometimes simple and percurrent, at other times connected by zigzag connections midway between adjacent secondaries. The whole venation facies is rather characteristic and readily recognizable, but difficult to describe.

The lower Eocene Montana-Wilcox form should be called *Meliosma*

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[1] Received May 2, 1939.

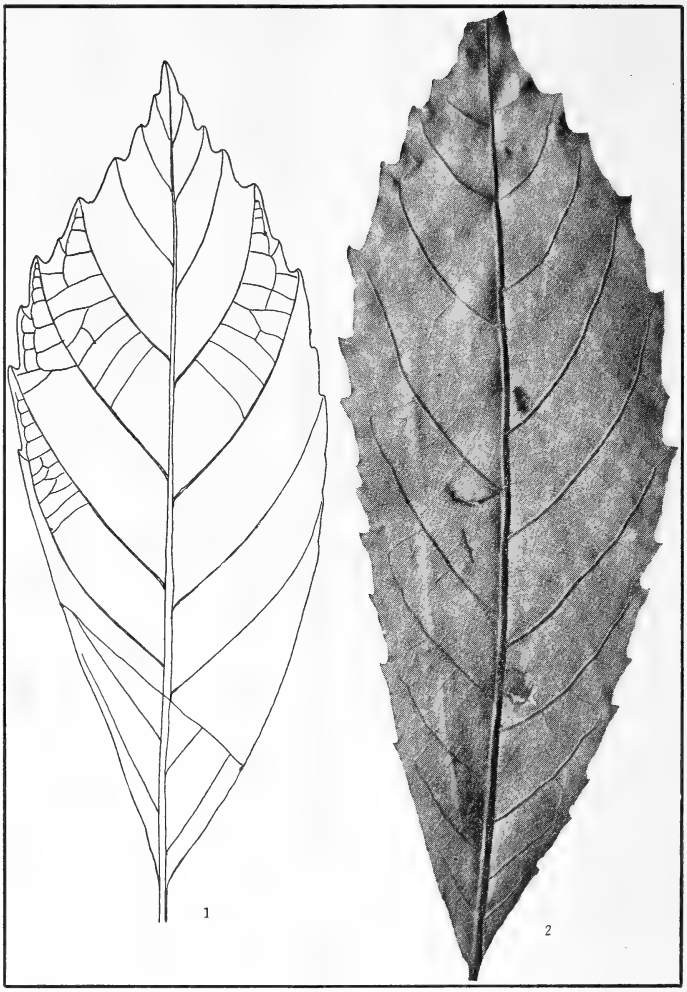
[2] NEWBERRY, J. S. Proc. U. S. Nat. Mus. **5**: 511. 1883.

[3] NEWBERRY, J. S. Mon. U. S. Geol. Surv. **35**: 130, pl. 57, fig. 2. 1898.

[4] BERRY, E. W. U. S. Geol. Surv. Prof. Paper **91**: 219. 1916.

[5] BERRY, E. W. *Ibid.* **156**: 71, pl. 12, fig. 10. 1930.

cuneata (Newberry). (See Fig. 1.) Its closest living analogues occur for the most part in Mexico and Central America. In general there is less close a resemblance to existing species in the Antilles, which are mostly entire; and those of eastern Asia, which are generally slenderer and have more regularity of dentition, although several of the latter are more like the Montana example than they are like the Wilcox forms.



Figs. 1, 2.—1, *Meliosma cuneata* (Newberry), Wilcox Eocene. 2, *Meliosma dentata* Urban, from Central America.

It is among the variable leaves of *Meliosma dentata* Urban and *Meliosma glabrata* (Liebm.) Urban of Central America that the fossil form can be most closely matched. The leaf of the former shown in Fig. 2 is not nearly so like the fossil as others of that species which I was unable to obtain for illustrating.

The fossil record of *Meliosma* is very incomplete, largely, I believe, because paleobotanists have been relatively ignorant of the foliar characters of some of the tropical families. The present Wilcox species is the oldest known leaf specimen, although Reid and Chandler[6] have described three species based on endocarps from the London clay of southeastern England (Sheppey), which is almost exactly the same age as the Wilcox (Ypresian). There is also a fruit from the Pliocene of Reuver and Swalmen[7] in Holland, which completes the known European records.

The additional American records include a fruit described by the present writer[8] from the lower Miocene of California and three species based upon leaves described by Chaney and Sanborn[9] from the upper Eocene Goshen flora of Oregon. One of these—*Meliosma goshenensis* Chaney and Sanborn[10]—is the most similar to the Wilcox species. These authors compare this species particularly with the existing *Meliosma panamensis* Standley, although calling attention to certain similarities in the living Chinese *M. rigida* S. & Z. and *M. simplicifolia* Roxb.

ZOOLOGY.—*A new allocreadiid trematode,* Podocotyle shawi, *n. sp., from the silver salmon.*[1] ALLEN McINTOSH, U. S. Bureau of Animal Industry.

The species described in this paper is based on 5 specimens that were recently forwarded for identification to the Bureau of Animal Industry by Dr. J. N. Shaw, Oregon State Agricultural College, Corvallis, Oreg. This species belongs to the genus *Podocotyle,* but since it does not appear to agree with any known member of the genus, it is regarded as new and is described below.

Podocotyle shawi, n. sp.

Description.—Body elongated, 4.1 mm long by about 1.1 mm wide, slightly constricted at equator, broadest at region of testes, anterior end more attenuated than posterior end; cuticula without spines. Oral sucker terminal, 310μ by 250μ; cuticula of inner wall of oral sucker appearing as if

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[6] Reid and Chandler. *London clay flora, British Museum.* 1933.

[7] C. and E. M. Reid. *Pliocene flora of the Dutch Prussian border,* p. 113, pl. 11, figs. 19–21, 24, 25. 1915.

[8] Berry, E. W. Journ. Washington Acad. Sci. **19**: 99, figs. 1, 2. 1929.

[9] Chaney and Sanborn. Carnegie Inst. Washington Publ. **439**: 84. 1933.

[10] *Ibid.* 84, pl. 28, figs. 2, 3; pl. 29, figs. 1–3.

[1] Received March 8, 1939.

provided with rasplike scales. Acetabulum pre-equatorial, 500μ by 450μ. Prepharynx about 150μ by 150μ; pharynx 200μ in diameter; esophagus 400μ by 50μ; intestinal crura ending near posterior end of body. Excretory pore at posterior end of body, opening into an elongated bladder. Testes from ovoid to almost spherical in outline, tandem and contiguous, situated in posterior half of body; anterior testis 380μ by 600μ, posterior testis 450μ by 550μ. Cirrus sac 1.7 mm long by about 100μ wide, extending along median line from near region of ovary, bending to pass acetabulum laterally to area

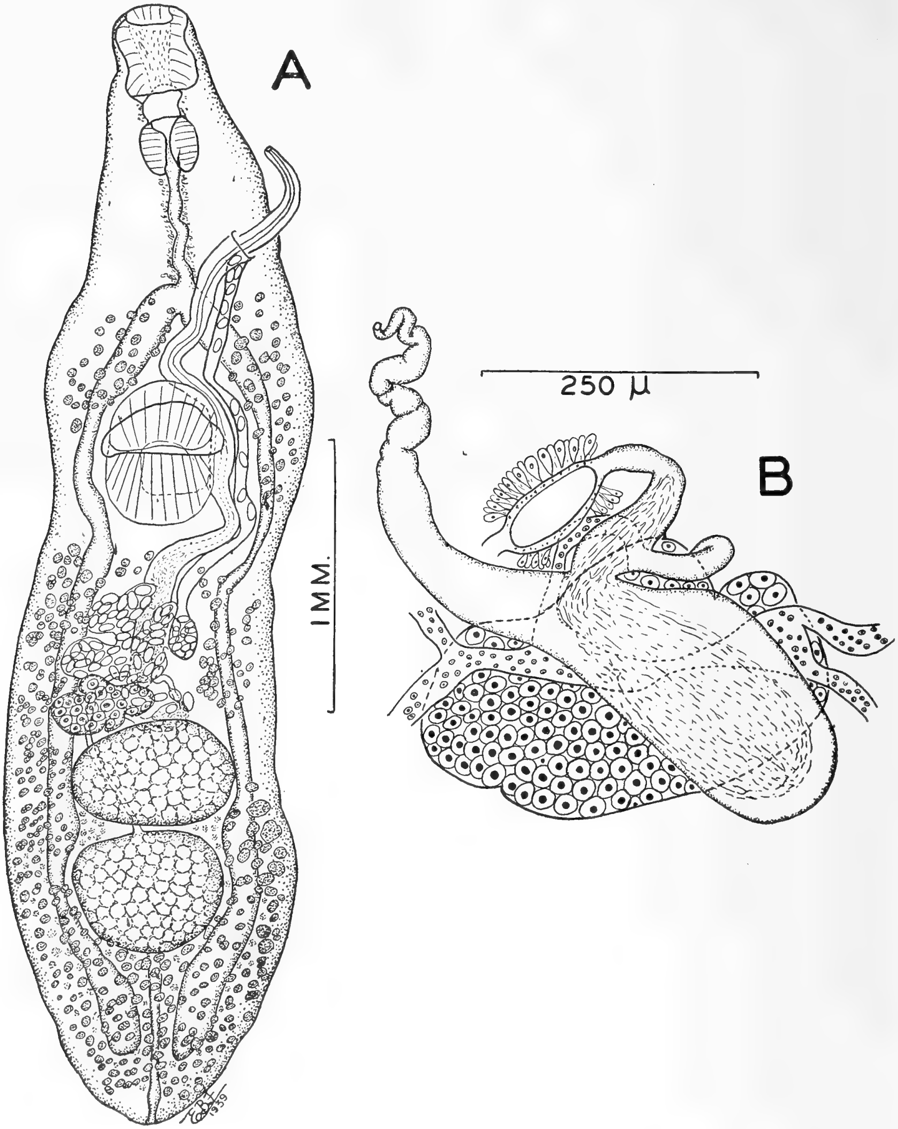

Fig. 1.—*Podocotyle shawi*, n. sp. A, Ventral aspect. B, Ovarian complex, dorsal aspect.

between acetabulum and cecal fork and then continuing diagonally to genital pore; cirrus spiny, protruding in type specimen beyond body margin. Genital pore located laterally about halfway between median line and margin of body in zone of posterior third of esophagus. Ovary lobed, 200μ by 380μ, median or lateral in position, pretesticular. Seminal receptacle dorsal to ovary, about 150 to 300μ; Laurer's canal extending anteriorly from large seminal receptacle. Vitellaria extending from level of intestinal fork to beyond cecal tips, usually with an interruption at basal level of acetabulum. Uterus between ovary and acetabulum, consisting of few coils. Metraterm elongated, to left of cirrus sac. Eggs about 78μ by 55μ, yellowish brown.

Habitat.—Intestine of silver salmon, *Oncorhynchus kisutch* (Walbaum).

Distribution.—Alsea River, Oregon, U. S. A.

Specimens.—U. S. N. M. Helm. Coll. nos. 43427 (type) and 43428 (paratypes).

Remarks.—In addition to the type specimens from *Oncorhynchus kisutch* there are several specimens in the Helminthological Collection of the Bureau of Animal Industry from the cutthroat trout (*Salmo clarkii* Richardson) and the steelhead trout (*Salmo gairdnerii* Richardson) that apppear to be identical with the specimens on which the new species is based; these specimens were also collected by Dr. Shaw from the same locality.

Podocotyle shawi differs from most of the other members of the genus in that the vitellaria on each side extend in front of the acetabulum to the level of the cecal fork. In a few species of the genus *Podocotyle,* namely, *P. atomon* var. *dispar* Nicoll, 1919, *P. lanceolata* Price, 1934, and *P. pennelli* Leiper and Atkinson, 1914, some few vitelline follicles, usually only on the right side, are present in front of the acetabulum; however, in these three species the cirrus sac is short in comparison with the elongated cirrus sac of *P. shawi.*

Recent contributions to our knowledge of the genus *Podoctyle* are to be found in papers by Price, 1934 (Smithsonian Misc. Coll. **91:** 1–8); McFarland, 1936 (Journ. Biol. Board Canada **2:** 335–347); and Park, 1937 (Journ. Parasit. **23:** 405–422). In the last-named paper a key to the species of the genus *Podocotyle* is given.

ENTOMOLOGY.—*A key to the larval Bostrichidae in the United States National Museum (Coleoptera).*[1] WILLIAM H. ANDERSON, U. S. Bureau of Entomology and Plant Quarantine. (Communicated by C. F. W. MUESEBECK.)

Twenty-one species are included in the accompanying key, which deals only with full-grown or nearly full-grown larvae. Twenty of the species are represented in the larval collection of the United States National Museum. The only species treated of which no larvae are contained in that collection is the cosmopolitan *Rhizopertha dominica* (F.), the distinguishing characters of which have been taken from the valuable paper by Gardner.[2] Except for *Dexicrates robustus* (Blanch.), all the species in the key occur in North America.

The family characters of larval Bostrichidae have been given in detail by Böving[3] and will not be repeated here. However, the scope of the family is here extended to include the Psoidae of Böving and Craighead.[4] The genera comprising this family, namely *Stephanopachys, Rhizopertha, Dinoderus, Polycaon,* and *Psoa,* were excluded from the Bostrichidae by those authors because they possess strong epipharyngeal sclerotization, a large pseudomolar process, and large fleshy lacinia mandibulae. That these characters are hardly sufficient for family separation was brought out by Gardner (l. c.), who showed that the larval mandible of the Bostrichini has a small fleshy appendage (lacinia mandibulae) and a small rodlike projection (pseudomola). Furthermore, although in habitus the imagoes of the Psoinae are somewhat divergent from those of the Bostrichinae, those of the Dinoderinae must be considered convergent. And a study of the larvae of Psoinae and Dinoderinae indicates the close relationship between the subfamilies. In addition, the biologies of the Psoinae and Dinoderinae are very similar to those of the Bostrichinae. It seems best, therefore, to include the Psoidae of Böving and Craighead in the Bostrichidae.

I agree with Gardner (l. c.) and Lesne[5] in considering *Dinoderus* and related genera (Dinoderinae) sufficiently distinct from the Psoinae to be worthy of subfamily rank. In the Dinoderinae the anterior

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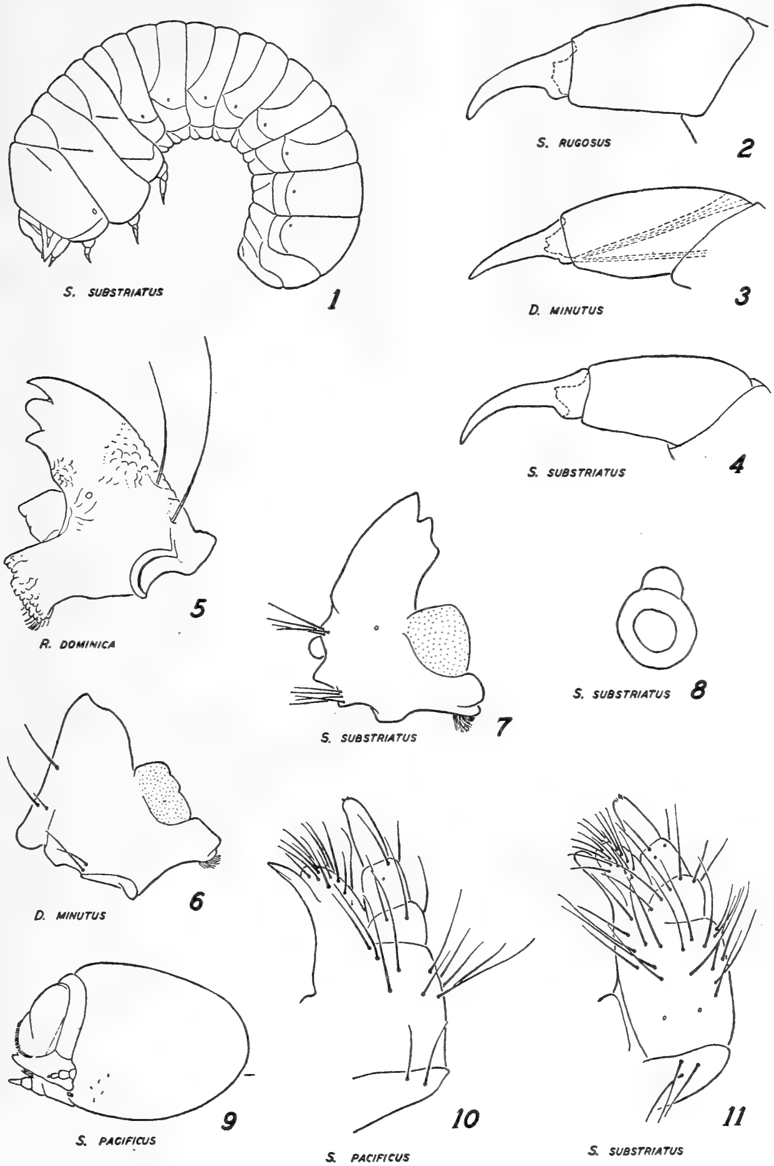
[1] Received March 22, 1939.

[2] GARDNER, J. C. M. *Immature stages of Indian Coleoptera (13) (Bostrychidae).* Indian Forest Rec., Ent. Ser. **18** (9): 1–19, 4 pls. 1933.

[3] BÖVING, ADAM G. *Taxonomy and morphology of the larval stages of* Scobicia declivis (*Lec.*). U. S. Dept. Agr. Bull. **1107** (appendix): 49–56, pls. 1–2. 1922.

[4] BÖVING, ADAM G., and CRAIGHEAD, F. C. *An illustrated synopsis of the principal larval forms of the order Coleoptera.* Ent. Amer. **11** (n.s.): 1–341, 125 pls. 1931.

[5] LESNE, PIERRE. *Les coléoptères bostrychides de l'Afrique Tropicale Française.* Paris, 288 pp., 210 figs. 1924.



Figs. 1–11.—1, *Stephanopachys substriatus* (Payk.), lateral view (body setae omitted). 2, *S. rugosus* (Oliv.), tibiotarsus and claw, left prothoracic leg (setae omitted). 3, *Dinoderus minutus* (F.), tibiotarus and claw, left prothoracic leg (setae omitted). 4, *Stephanopachys substriatus*, tibiotarsus and claw, left prothoracic leg (setae omitted). 5, *Rhizopertha dominica* (F.), right mandible, dorsal view (adapted from Gardner, *l. c.*, fig. 34). 6, *Dinoderus minutus*, left mandible, dorsal view. 7, *Stephanopachys substriatus*, left mandible, dorsal view. 8, *S. substriatus*, spiracle from third abdominal segment. 9, *S. pacificus* Csy., head, dorsolateral view (setae, for the most part, omitted). 10, *S. pacificus*, left maxilla, ventral view. 11, *S. substriatus*, left maxilla, ventral view. Except for Fig. 5, all drawings are by the author.

abdominal terga have only two folds and the prothorax lacks a lateral thickening, whereas in the Psoinae there are four tergal folds and the prothorax possesses a lateral thickening.

There seem to be excellent reasons for maintaining the Lyctidae as a distinct family, although Gardner (l. c.) and Lesne (l. c.) have treated them as a subfamily (Lyctinae) of the Bostrichidae. The Lyctidae are undoubtedly closely related to the Bostrichidae, especially through the Dinoderinae and Psoinae, which resemble the Lyctidae in the shape of the head, the structure of the mouth parts, the development of the legs and their position at rest, and the enlargement of the thorax. It is probable that the similarity of food and of feeding habits is largely responsible for these resemblances. Other, less adaptive characters show the two groups to be distinct.

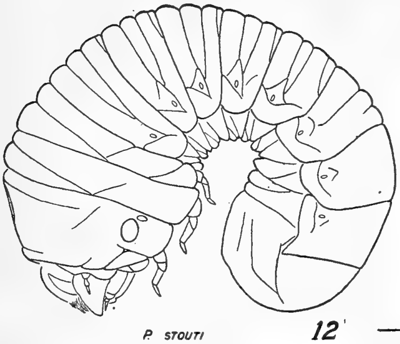
An important difference is found in the lobes around the anal opening. The tenth abdominal segment of the Bostrichidae, in front of the anus, has a pair of adjacent lobes separated by a longitudinal groove. In the Lyctidae, however, the tenth abdominal segment lacks the longitudinal groove and folds in front of the anus, the anal opening being surrounded by a transverse anterior and two lateral lobes.

A structure that probably has considerable significance is found in the posterior portion of the intestine. It consists of a pair of slender, apparently sclerotized rods, which lie in, or inseparably on, the wall of the intestine. In the Bostrichidae they begin at the lateral margins of the longitudinal groove in front of the anus and extend anteriorly in spirals. The spirals run clockwise for two or three turns, then reverse and run counterclockwise for one or two more turns. The rods then unite and end blindly. In the Lyctidae these supporting rods simply follow along the ventral wall of the intestine without winding spirally, around it.

The eighth abdominal spiracle in the Lyctidae is comparatively huge, whereas in the Bostrichidae it is not larger than other abdominal spiracles.

The pupae of the two families show little of significance, interpreted by our present knowledge, which would separate them. There is a difference in the habitus that is in agreement with the habital difference between the imagoes, the Lyctidae being usually more strongly depressed and less compact.

There is a significant difference in the male genitalia of the two families. In the Bostrichidae the axis of the aedeagus is parallel to that of the body. The genitalia of the Lyctidae, on the other hand, are somewhat asymmetrical in that the sclerotized parts are curved in



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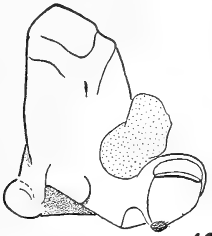

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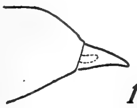

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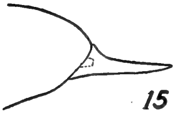

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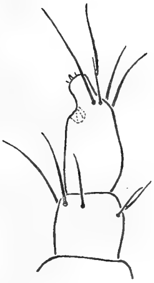

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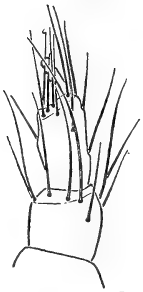

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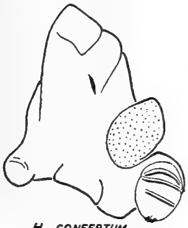

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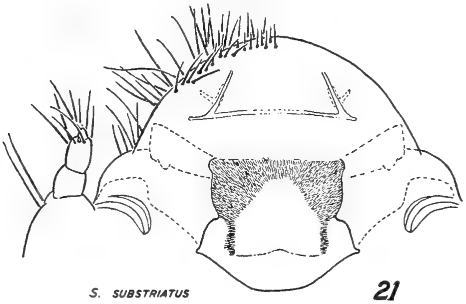

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Figs. 12–21.—12, *Polycaon stouti* (Lec.), lateral view (body setae omitted). 13, *P. stouti*, right mandible, buccal view. 14, *Psoa maculata* (Lec.), tarsal claw, right prothoracic leg. 15, *Polycaon stouti*, tarsal claw, right prothoracic leg. 16, *P. stouti*, antenna. 17, *Psoa maculata*, antenna. 18, *Heterarthron plicatum* (Lec.), antenna. 19, *H. confertum* (Lec.), antenna. 20, *H. confertum*, right mandible, buccal view. 21, *Stephanopachys substriatus*, epipharynx. All drawings by the author.

such a manner that the posterior extremities of the lobes are not in the midline of the body. Furthermore a distinct torsion of the aedeagus has taken place in the Lyctidae, probably as a result of the curvation.

It seems advisable to discuss briefly a few of the structures used in the key. Some of them have not been studied before in this family, and one structure has, at times, been misinterpreted.

Arising from the ventral surface of the labral sclerite there is a pair of stout sclerotized processes, the so-called "epipharyngeal rods." They extend vertroposteriorly through the pocketlike space between labrum and epipharynx and become secondarily attached to the dorsal surface of the epipharyngeal membrane. On the ventroposterior end of each rod, muscles are inserted which usually originate within the head and are responsible for the principal movements of the labrum.

Beneath the floor of the pharynx, immediately behind the buccal cavity, there is a forwardly directed U-shaped sclerome (Fig. 43). This has been termed the fulcrum. Extending posteriorly and somewhat dorsally along the walls of the pharynx from the arms of this sclerome there is, in most species, a supplementary pair of rods (Fig. 38). Muscles are attached to these rods[6] which assist in the tilting of the floor of the pharynx, and hence in opening or closing it.

The antenna consists of three articles except when the second and third have fused. In the latter case the distal end of the second can be located by the uniformly present, supplementary, conical, sensory appendix. In addition to the three articles there is a rather prominent basal membrane by which the antenna is connected to the head. By some investigators of this and other families this membrane has been considered as the basal article. An examination of the antennal muscles shows this conception incorrect since, from their origin within the head, the muscles can be traced to the base of the first article, and are not inserted on the membranous ring.

The bostrichid larvae in the United States National Museum are readily separable into the three subfamilies Dinoderinae, Psoinae, and Bostrichinae. That these are natural groups is shown both by larval characteristics and by the structure of the male genitalia.

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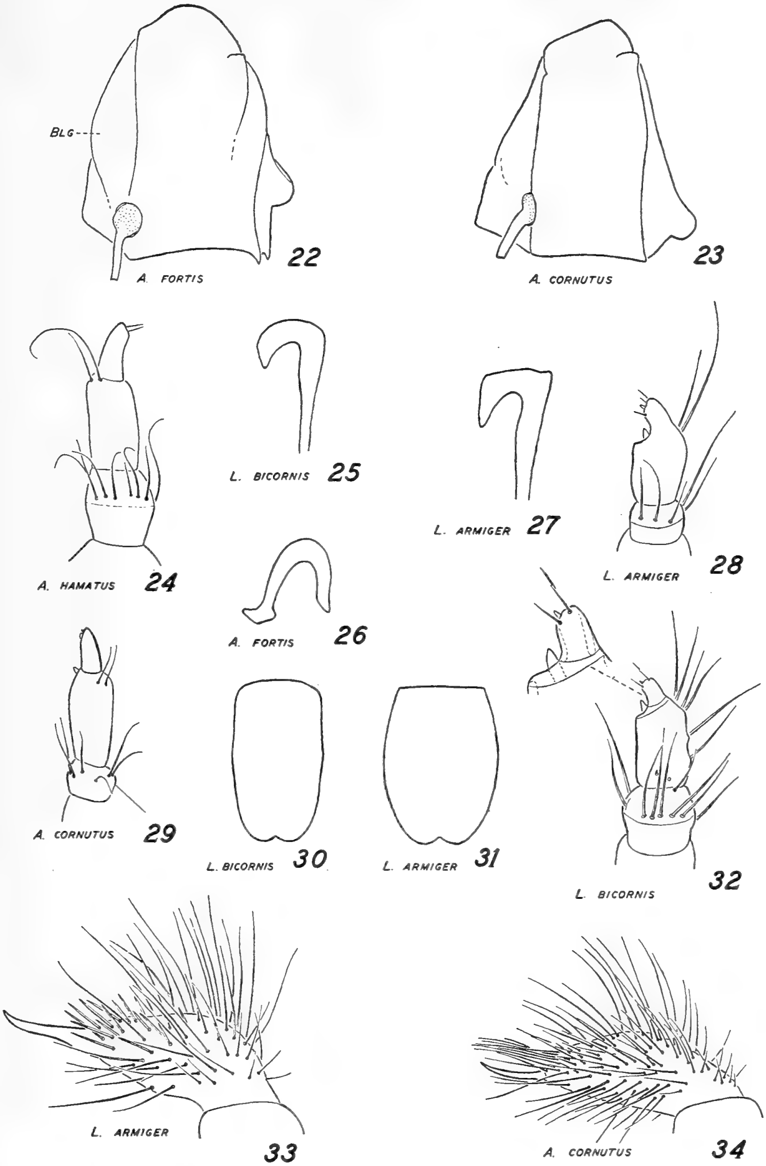
[6] It is, of course, impossible to consider these rods as being, as Pringle stated, "upwardly directed into the mouth cavity." PRINGLE, J. A. *Observations on certain wood-boring Coleoptera occurring in South Africa.* Trans. Roy. Ent. Soc. London **87** (11): 247–270, 1 pl., 5 figs. 1938.



Figs. 22–34.—22, *Apatides fortis* (Lec.), left mandible, buccal view (BLG, dorsal bulge). 23, *Amphicerus cornutus* (Pallas), left mandible, buccal view. 24, *A. hamatus* (F.), antenna. 25, *Lichenophanes bicornis* (Web.), epipharyngeal rod, lateral view. 26, *Apatides fortis*, epipharyngeal rod, lateral view. 27, *Lichenophanes armiger* (Lec.), epipharyngeal rod, lateral view. 28, *L. armiger*, antenna. 29, *Amphicerus cornutus*, antenna. 30, *Lichenophanes bicornis*, outline of foramen. 31, *L. armiger*, outline of foramen. 32, *L. bicornis*, antenna. 33, *L. armiger*, tibiotarsus and claw, left prothoracic leg. 34, *Amphicerus cornutus*, tibiotarsus and claw, left prothoracic leg. All drawings by the author.

KEY TO SPECIES STUDIED

1. Abdominal segments 1 to 5 with two tergal folds (Fig. 1); labial palpus with one article; prothorax without lateral thickening (Dinoderinae) . 2
   Abdominal segments 1 to 5 with three or four tergal folds (Fig. 12); labial palpus with two articles; prothorax laterally with oblique rodlike thickening or with oval raised area........................6

Dinoderinae (*couplets 2–5 inc.*)

2. Head without subcutaneous pigment spots or ocelli; spiracles simple, oval...3
   Head with pigment spots (usually 5) and an ocellus (Fig. 9); each spiracle with a dorsal oval projection (Fig. 8)..........................4
3. Mandible with three teeth; molar part granular (Fig. 5)..............
   ....*Rhizopertha dominica* (F.)
   Mandible oblique, with one projecting tooth; molar part smooth (Fig. 6)
   ....*Dinoderus minutus* (F.)
4. Claw of prothoracic leg robust, subequal in length to width of tibiotarsus (Fig. 2)[7]; ventral pigment spot of head largest..................
   ....*Stephanopachys rugosus* (Oliv.)
   Claw of prothoracic leg slenderer, $1\frac{1}{4}$ to $1\frac{1}{2}$ times width of tibiotarsus (Fig. 4); ventral pigment spot not larger than others (Fig. 9)......5
5. Stipes with numerous setae (Fig. 11). *Stephanopachys substriatus* (Payk.)
   Stipes with few setae (Fig. 10)..........*Stephanopachys pacificus* Csy.
6. Mandible with large pseudomola and with large fleshy appendage (Fig. 13); epipharynx with large median sclerome (Fig. 21); maxillary palpus with three articles (Psoinae)...........................7
   Mandible without large pseudomola, either with (Fig. 46) or without (Fig. 44) a small rodlike projection; epipharynx without median sclerome; maxillary palpus with two articles (Bostrichinae).......11

Psoinae (*couplets 7–10 inc.*)

7. Mandibular molar part with three transverse ridges (Fig. 20)........8
   Molar part with one transverse ridge (Fig. 13).....................9
8. Prothoracic tarsal claw stout; clypeus lightly pigmented; antenna clearly with three articles (Fig. 18)............*Heterarthron plicatum* (Lec.)
   Prothoracic tarsal claw slender; clypeus heavily pigmented; antenna with second and third articles apparently fused (Fig. 19)..........
   ....*Heterarthron*[8] *confertum* (Lec.)

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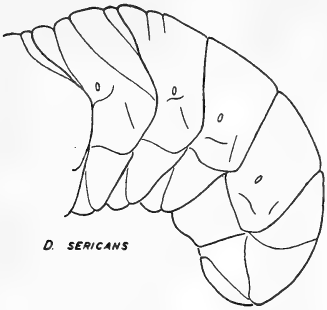
[7] The tarsal claw of bostrichid larvae has been considered immovably united with the tibiotarsus. In certain species (cf. Fig. 3) that have been investigated in this study the full quota of muscles is present and extends from the claw into tibiotarsus and femur. It seems logical, therefore, that the claw is independently movable.

[8] The use of *Heterarthron* in place of *Polycaon* for these two species seems justified, since they are not congeneric with *Polycaon stouti* (Lec.). *Lichenophanes bicornis* (Web.) has been used in place of *Bostrichus bicornis* (Web.) because *bicornis* appears congeneric with *L. armiger* (Lec.). Lesne has expressed these same opinions in his recent catalogue: Lesne P. Bostrychidae, in *Coleopterorum catalogus* (W. Junk) **10** (161). 1938.



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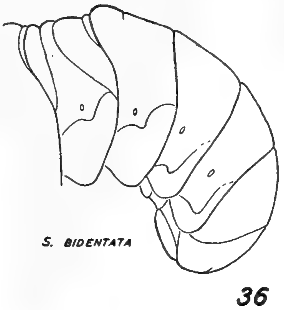

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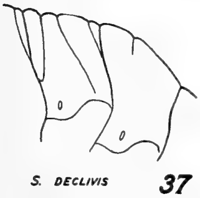

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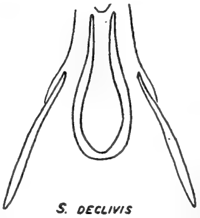

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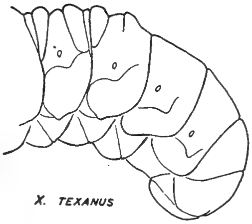

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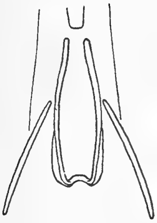

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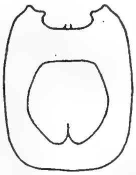

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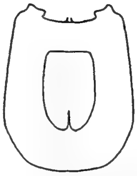

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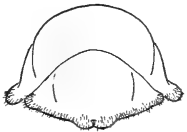

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Figs. 35–46.—35, *Dendrobiella sericans* (Lec.), posterior half of abdomen. 36, *Scobicia bidentata* (Horn), posterior half of abdomen. 37, *S. declivis* (Lec.), fifth and sixth abdominal terga. 38, *S. declivis*, pharyngeal fulcrum. 39, *Xylobiops texanus* (Horn), posterior half of abdomen. 40, *Dendrobiella sericans*, pharyngeal fulcrum. 41, *D. sericans*, head capsule, ventral view. 42, *Scobicia bidentata*, head capsule, ventral view. 43. *Xylobiops texanus*, pharyngeal fulcrum. 44. *Dendrobiella sericans*, left mandible, dorsal view. 45, *D. sericans*, tip of abdomen, posterior view. 46, *Apatides fortis*, left mandible, dorsal view. All drawings by the author.

9. First article of antenna robust, bearing many setae (Fig. 16); mentum very hairy..10
First article of antenna normally developed, with but few setae (Fig. 17); mentum sparsely setose; [prothoracic tarsal claw stout (Fig. 14)]..*Psoa maculata* (Lec.)

10. Pigmentation on outer face of stipes long, extending about one-half distance from cardo to base of palpiger; submentum bearing many long, silky hairs..*Dexicrates robustus* (Blanch.) (from South America)
Pigmentation on outer face of stipes not evident; submentum with fewer, shorter hairs; [prothoracic tarsal claw slender (Fig. 15)]...*Polycaon stouti* (Lec.)

Bostrichinae (*couplets 11–20 inc.*)

11. Maxillary mala with freely projecting stylet; mandible with small rodlike projection (Fig. 46) (Bostrichini)........................12
Maxillary mala without stylet; mandible without rodlike projection (Fig. 44) (Xyloperthini)......................................16

12. Terminal setae of prothoracic tibiotarsus subequal in length with claw and forming a compact "brush" (Fig. 34); epipharyngeal rod short (Fig. 26); antenna with third article distinct, subequal in length to first article (Fig. 24)...13
Terminal setae of prothoracic tibiotarsus stout, much shorter than claw and not forming a "brush" (Fig. 33); epipharyngeal rod long (Fig. 25); antenna with third article shorter than first and apparently fused with second article (Fig. 28)....................................15

13. Mandible with outer face dull and with dorsal bulge (Fig. 22, BLG.) prominent, gently receding from plane of inner face...*Apatides fortis* (Lec.)
Mandible with outer face shiny and with dorsal bulge not prominent (Fig. 23), sharply receding from plane of inner face.............14

14. First article of antenna long, slightly less than one-third total length of antenna (Fig. 24)....................*Amphicerus hamatus* (F.)
First article of antenna short, about one-fifth total length of antenna (Fig. 29)..........................*Amphicerus cornutus* (Pallas)

15. Opening of foramen broad, lateral margins smoothly curved (Fig. 31)..................................*Lichenophanes armiger* (Lec.)
Opening of foramen narrow, lateral margins nearly straight (Fig. 30)..................................*Lichenophanes bicornis* (Web.)

16. Tarsal claw cleft; antenna shorter than maxillary palpus; mandible oblique, pointed.........................*Dinapate wrighti* Horn
Tarsal claw simple; antenna longer than maxillary palpus; mandible gouge-shaped..17

17. Posterior extensions from pharyngeal fulcrum not developed as pigmented rods (Fig. 43)...18

Posterior extensions from pharyngeal fulcrum developed as pigmented rods (Fig. 38) 19

18\. Claws on second and third pairs of legs pigmented; scutum and scutellum of sixth abdominal segment forming a conspicuous transverse ridge (Fig. 39) .... *Xylobiops texanus* (Horn)

Claws on second and third pairs of legs not pigmented; scutum and scutellum of sixth abdominal segment not forming a conspicuous ridge .... *Xylobiops basillaris* (Say)

19\. Sixth abdominal segment, dorsally, divided into two transverse areas (Fig. 36); lateral margins of foramen straight, nearly parallel (Fig. 42); anal lobes prominent 20

Sixth abdominal segment, dorsally, divided into three transverse areas (Fig. 35); lateral margins of foramen strongly curved (Fig. 41); anal lobes less prominent (Fig. 45) .... *Dendrobiella sericans* (Lec.)

20\. Scutum of sixth abdominal segment prominent (Fig. 36) .... *Scobicia bidentata* (Horn)

Scutum of sixth abdominal segment not prominent (Fig. 37) .... *Scobicia declivis* (Lec.)

ENTOMOLOGY.—*New ichneumon-flies parasitic on the hemlock sawfly* (Neodiprion tsugae *Middleton*).[1] R. A. CUSHMAN, U. S. Bureau of Entomology and Plant Quarantine. (Communicated by C. F. W. MUESEBECK.)

Recent outbreaks of conifer-feeding sawflies of the genera *Diprion* and *Neodiprion*, both introduced and native species, have greatly increased the interest in and economic significance of the parasites of such insects. This has resulted in the rearing of large numbers of the parasites, many representing undescribed species, for which names are desired for use in economic and biological papers.

This paper consists of the descriptions of eight new species parasitic on the hemlock sawfly, *Neodiprion tsugae* Middleton, together with a few taxonomic and nomenclatorial notes pertinent to the main subject.

Genus **Ischnus** Gravenhorst

Ischnus Gravenhorst, Ichneumonologica Europaea **1**: 638. 1829.—Viereck, U. S. Nat. Mus. Bull. **83**: 78. 1914.

Habrocryptus Thomson, Opuscula entomologica, fasc. **5**: 471, 498. 1873.—Schmiedeknecht, Opuscula ichneumonologica, fasc. **7**: 502. 1904.

This is the *Ischnus* of the genotype, *porrectorius* (F.), not the phaeogenine genus *Ischnus* of European works. To it should be referred the following North American species:

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[1] Received May 20, 1939.

Ischnus amblytelarius (Provancher), n. comb.

Cryptus amblytelarius Provancher, Additions et corrections au volume II de la faune entomologique du Canada . . . p. 70. 1886.

Ischnus atricollaris (Walsh), n. comb.

Cryptus atricollaris Walsh, Trans. St. Louis Acad. Sci. **3**: 72. 1873.

Ischnus polychrosidis (Cushman), n. comb.

Spilocryptus polychrosidis Cushman, Proc. U. S. Nat. Mus. **53**: 461. 1917.

Ischnus oregonensis, n. sp.

From the foregoing three species this species is easily distinguished by its entirely impunctate abdomen and distinctly convex (in front view) cheeks. Also the thorax never has any ferruginous color, although the propodeum is rarely partly piceous.

Female.—Length 6–8 mm (holotype 8 mm).

Head mat; temples strongly receding, convex; frons with a narrow, shining, median groove, scrobes also shining; eyes slightly divergent below antennae; clypeus strongly convex, small, shining; cheeks in front view convex; malar space as long as basal width of mandible; antenna distinctly shorter than body, 31-jointed, slender, filiform, first joint of flagellum nearly 6 times as long as thick, second only slightly shorter.

Thorax mat; pronotum mostly striato-rugulose; mesoscutum, scutellum, and pleura minutely punctate, the scutum and pleura confluently so, speculum polished; propodeum finely rugulose, dorsal face short, posterior face nearly vertical, transverse carinae distinct, apical carina sometimes obsolete medially but strong at angles; sides of areolet distinctly convergent toward radius, but their upper ends rather widely separated.

Abdomen granularly mat, impunctate, only the petiole dorsally shining; sheath of ovipositor about a half longer than first segment.

Black, with abdomen and legs ferruginous, front coxa and sometimes others more or less piceous, hind tibia (except base) and tarsus fuscous; anterior orbit and short streaks behind and above eye and a triangular spot in malar space whitish; labrum whitish; clypeus and mandibles piceous; palpi and flagellum fuscous; collar and usually a narrow humeral margin of pronotum whitish; tegulae brown; propodeum sometimes more or less reddish posteriorly (in holotype there is a streak of this color along median portion of apical carina); wings subhyaline, venation black.

Male.—Length 6–7 mm.

Much slenderer than female, with propodeum more evenly rounded and less precipitous and with weak carinae; genital sheath abruptly very slender apically. Head and thorax copiously white-marked, this color including face, clypeus, mandibles, palpi, malar space, broad orbital ring (interrupted only behind top of eye), underside of scape, ventral portion of propleuron, broad collar and humeral margin of pronotum, median spot on mesoscutum, scutellum, tegula, subalar tubercle, spots on lower mesopleuron, metapleuron and center of propodeum, front and middle coxae and trochanters, and a spot dorsally on hind coxa; hind coxa and basal joint of trochanter piceous; wings hyaline; petiole and apex of abdomen black.

Host.—*Neodiprion tsugae* Middleton.

Type locality.—Sweet Home, Oreg.

Holotype, allotype, and *paratypes.*—U.S.N.M. no. 53343.

Paratypes.—Canadian National Collection; California Academy of Sciences.

Thirteen females and 18 males (including holotype female and allotype male, a mated pair), all reared at the type locality from *Neodiprion tsugae* under N. E. For. Ins. Lab. no. 51.201, during June and October; 2 ♀ and 5 ♂ reared from type host at type locality under Hopk. U. S. nos. 31607-S, 31660-F, and 18875-F, during May, August, and September; 1 ♀ and 1 ♂, West Yellowstone, Mont., from sawfly on lodge-pole pine, Hopk. U. S. nos. 18088-F, Aug. 13, 1926 (♀), 18088-E, 1925 (♂); and 1 ♂, West Yellowstone, Mont., Hopk. U. S. no. 17243-B, April 9, 1925.

Spilocryptus neodiprionis, n. sp.

From *Spilocryptus lophyri* (Norton), which is also parasitic on species of the genus *Neodiprion,* this species can be distinguished at once, in the female, by the entire lack of yellow markings on the head and thorax, and in the male by the black face and orbits, only the clypeus and mandibles being white, whereas in *lophyri* the orbits, and in the male, usually the middle of the face, are white-marked.

Female.—Length 5.5–8 mm (holotype 8 mm).

Head mat, face densely and postvertex more sparsely punctate, frons medially rugulose, lower cheeks polished; temples very strongly receding, weakly convex; clypeus strongly convex, shining; malar space about as long as basal width of mandible; antenna three-fourths as long as body, 26- to 27-jointed, slender, filiform, first joint of flagellum six times as long as thick at apex, subapical joints definitely longer than thick.

Thorax dorsally shining, mesothorax densely and finely punctate and scutellum sparsely so; pronotum mostly striate; mesopleuron and metapleuron finely rugulose, mat; sternum shining, finely punctate; propodeum more coarsely rugulose than pleura; apical carina rather prominent laterally, broadly interrupted medially; sides of areolet slightly convergent, recurrent at or slightly beyond middle of areolet.

Abdomen very minutely coriaceous, with minute scattered punctures on basal tergites and with rather dense and very fine appressed silvery pubescence; first tergite impunctate and glabrous dorsally, the petiole polished; sheath of ovipositor barely longer than first segment.

Black, with basal three abdominal segments and legs ferruginous; a median spot on tergite 7 and usually an incomplete annulus centering on flagellar joints 7–8 white; antenna reddish fuscous, scape redder; tegulae piceous; hind femur apically and tibia dorsally blackish; wings subhyaline, venation black.

Male.—Length 5.5–7 mm.

More slender than female and with propodeum more evenly rounded because of much weaker apical carina; clypeus, mandibles, palpi, and tegulae whitish; antenna without trace of annulus; legs paler, especially front and middle coxae and trochanters and joints 2–4 of hind tarsus, the tarsus otherwise darker than in female; tergites 4 and 5 also ferruginous, some or all of the red tergites frequently more or less spotted or banded at base with black; tergite 7 without white spot.

Host.—*Neodiprion tsugae* Middleton.

Type locality.—Sweet Home, Oreg.

Holotype, allotype, and *paratypes.*—U.S.N.M. no. 53344.

Paratypes.—Canadian National Collection; California Academy of Sciences.

Described from 27 females and 29 males all reared from the host in April, May, June, and October 1936, under N. E. For. Ins. Lab. no. 51.201. Included are five mated pairs, identified by the added number 36.2, of which the holotype female and allotype male are one pair.

Unlike most species of the genus, this lacks the conspicuous white annulus at the base of the hind tibia.

Aptesis (Pezoporus) tsugae, n. sp.

Unusual in the form of the areolet, which is nearly parallel-sided.

Female.—Length 5–8.5 mm (holotype 8.5 mm).

Head narrower than thorax, finely coriaceous, somewhat shining; temples convex, receding; vertex and frons medially grooved; scrobes shallow, subpolished; eyes divergent below, antennae not far above inferior tangent of eyes; face with a small, round, median elevation; clypeus small, strongly convex, apically truncate; malar space as long as basal width of mandible; antenna about two-thirds as long as body, stout filiform, 25- to 27-jointed, first joint of flagellum slightly shorter than second and about two and a half times as long as thick.

Thorax stout; pronotum mat, finely striato-coriaceous; mesoscutum shining and faintly punctate laterally, densely and finely punctate medially, notaulices fine and distinct anteriorly; scutellum polished, sparsely punctate; mesopleuron shining, indefinitely coriaceous and sparsely and weakly punctate, fovea very deep; sternum shining and sparsely punctate; metapleuron mat, finely coriaceous; propodeum short dorsally, precipitous and concave posteriorly, basal area and areola confluent, basal carina obsolete, apical strong, basal lateral and petiolar areas coriaceous, surface elsewhere rugulose; legs moderately stout; areolet nearly parallel-sided, second intercubitus mostly bullate, second recurrent slightly before middle of areolet; nervulus slightly postfurcal, postnervulus broken nearly at middle; nervellus broken near bottom and strongly inclivous.

Abdomen broad, coriaceous, mat; sheath of ovipositor about as long as first segment.

Black; inner orbits, a more or less definite incomplete annulus on flagellar joints 7–9, tegulae, wing radices, and a more or less distinct line on humeral margin of pronotum white or whitish; face medially, and clypeus and mandibles more or less, reddish; antenna apically and ventrally reddish; thorax black, sometimes piceous or ferruginous laterally and ventrally; legs ferruginous; wings hyaline, venation blackish; abdomen normally black, with reddish tinge, especially at apices of tergites, but frequently more definitely reddish especially on tergites 1–3.

Male.—Length 5.5–7 mm (allotype 6.5 mm).

Much more slender than female, with antenna tapering and nearly as long as body, joint 1 of flagellum distinctly longer than 2 and three times as long as thick; malar space much shorter than basal width of mandible; eyes parallel; antenna not far below middle of eye; propodeum longer above and shorter behind, with petiolar area more sloping and more weakly concave.

Color as in female, but with less tendency to red on thorax and abdomen; antennae entirely black; white markings more extensive, including face, clypeus, mandibles, palpi, and front and middle coxae and trochanters; hind coxa and trochanter piceous, apically whitish; hind tibia apically and tarsus blackish.

Host.—*Neodiprion tsugae* Middleton.

Type locality.—Sweet Home, Oreg.

Holotype, allotype, and *paratypes.*—U.S.N.M. no. 53345.

Paratypes.—Canadian National Collection; California Academy of Sciences.

Thirty-six females and 33 males, all from the type locality and all reared from *Neodiprion tsugae,* 30 females and 31 males under N. E. For. Ins. Lab. no. 51.201. Included in this series are five mated pairs, of which the holotype female and allotype male are one pair. The other 6 females and 2 males were reared under Hopk. U. S. nos. 31607–204, 31660-V, 31660-Q, and 31675-V.

Genus **Thysiotorus** Foerster

In his *Type species of the genera of ichneumon flies*[2] Viereck designated, as the type of *Thysiotorus* Foerster, *Hemiteles* (*Physiotorus*) *brevipennis* Brischke, assuming Brischke's spelling of the subgeneric name to be a typographical error.

The genus was originally characterized only by the few characters leading to it in Foerster's key to his family Phygadeuontoidae, and no species was assigned to it. The first couplet in the key definitely excludes Brischke's two species from *Thysiotorus,* for they are described as having the wings short, and quite obviously would run not to *Thysiotorus* but to *Phyrtus,* and one wonders if the name *Physiotorus* was not a lapsus for *Phyrtus* on the part of Brischke rather than a printer's error in the spelling of *Thysiotorus.* In any event, it is obvious that neither of the two species referred to *Physiotorus* by Brischke can properly serve as genotype of *Thysiotorus.*

The next inclusion of a species in *Thysiotorus* was by Viereck,[3] who referred *Mesoleptus? peregrinus* Cresson to the genus. I have already shown[4] that this species can not be accepted as the genotype, since it disagrees with the original description of the genus.

In Foerster's key *Thysiotorus* is grouped with *Panargyrops* and *Apsilops* (as though their author considered them related) on three characters: Long, slender, basal joints of flagellum, silky-haired face, and long deep notaulices. By these same three characters with others, Thomson characterized his genus *Leptocryptus,*[5] including in it *claviger* Taschenberg, properly designated by Viereck as genotype of *Panargyrops* and of the synonymous

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[2] U. S. Nat. Mus. Bull. **83**: 145. 1914.
[3] Proc. U. S. Nat. Mus. **42**: 645. 1912.
[4] *Ibid.* **58**: 258, 260. 1920.
[5] Opuscula entomologica, fasc. **10**: 963–966. 1884.

Leptocryptus. Also included in *Leptocryptus* is *L. lamina* Thomson, which agrees perfectly with the published description and also with Foerster's detailed unpublished description of *Thysiotorus*. I have already[4] referred *lamina* Thomson and *smithi* Cushman doubtfully and *Mesoleptus triangularis* Cresson positively[6] to *Thysiotorus*, and I am now convinced that they are properly to be referred to the genus. Viereck[7] apparently had no such doubt with regard to *smithi*, for he definitely referred it to *Thysiotorus*, thereby making it the first species properly so referred.

The following alterations to Viereck's genotype catalogue are therefore proposed:

Physiotorus Brischke (not *Thysiotorus* Foerster).
  Schrift. Naturf. Ges. Danzig **7** (N.F.): 71. 1891. Two species.
  Type.—Hemiteles (*Physiotorus*) *brevipennis* Brischke (by designation of Viereck, U. S. Nat. Mus. Bull. **83**: 116. 1914).
Thysiotorus (Foerster) Viereck.
  Verh. Naturh. Ver. Preuss. Rheinlande **25**: 81. 1868. No species.
  Can. Ent. **57**: 77. 1925. One species.
  Type.—(*Thysiotorus* ? *smithi* Cushman) = (*Mesoleptus*) *Thysiotorus triangularis* (Cresson), new synonymy. By present designation; *Hemiteles* (*Physiotorus*) *brevipennis* Brischke (by designation of Viereck, U. S. Nat. Mus. Bull. **83**: 145. 1914) does not agree with original description and is therefore not available as genotype.

The above entries should replace the earlier emendations to the type catalogue proposed by me[4] under the headings "*Thysiotorus* Brischke, not Foerster" and "*Thysiotorus* Foerster."

The following is a free translation of Foerster's manuscript description:

THYSIOTORUS Foerster

Clypeus weakly separated from face, flat, rounded at apex and transversely impressed, without apical denticles, but slightly projecting medially; face and clypeus covered with long silky hair; clypeal foveae and malar space with much denser hairs, these hairs curved—not long, straight, and weak as those on the face and clypeus; teeth of mandible of equal length; first joint of flagellum longer than second; mesoscutum with notaulices deep and complete; propodeum with long hair, completely areolated; first abdominal segment slender, little broadened toward apex, fringed laterally by long erect hair, spiracles slightly behind middle; second segment with thyridia far from base, spiracles behind middle; nervellus not broken; second discoidal cell a little or distinctly broader at base than the brachial cell at apex; discocubitus broken; hind calcaria less than one-third as long as basitarsus; fifth tarsal joint somewhat shorter than third.

Following the description in Foerster's manuscript is a key to nine manuscript species.

Thysiotorus latifrons, n. sp.

Similar to *triangularis* (Cresson), but with smaller eyes, broader face, longer malar space, more shining propodeum, and open areolet.

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[6] Proc. U. S. Nat. Mus. **74** (16): 58. 1927.
[7] Can. Ent. **57**: 77. 1925.

Female.—Length 5.5 mm, antenna 4 mm.

Head with dense silvery pubescence, longest on face and sides of frons; combined face and clypeus as broad as long; eyes very slightly convergent; clypeus convex, transversely impressed before the bidenticulate apex, foveae covered by tufts of long curved hairs; malar space two-thirds as long as basal width of mandible; temple convex, strongly receding, two-thirds as long (in dorsal view) as short diameter of eye; diameter of lateral ocellus longer than postocellar line and nearly as long as ocellocular line; antenna 26-jointed.

Thorax shining, with long silvery pubescence; pronotum laterally largely polished and glabrous, as is also a large area on mesopleuron embracing speculum and a deep, oblique impression; propodeum shining, especially medially, where it is virtually hairless, apical carina nearly at middle of dorsal length, areola large with costulae far before middle; areolet open at apex, the second intercubitus barely indicated.

Abdomen elongate fusiform, widest at apex of third segment; first tergite scarcely twice as broad at apex as at base, spiracles barely behind middle, postpetiole laterally striate; tergites 2 and 3 longitudinally striate, polished apically, polished areas longer medially; other tergites, except finely punctate base of 4, unsculptured; ovipositor sheath about as long as first segment.

Black; mandibles reddish; palpi, scape below, front and middle legs, tegulae, and small humeral angles of pronotum stramineous to whitish; tergites pale reddish stramineous apically, 2 to 4 triangularly so; front tarsus apically and middle tarsus except base black; hind coxa, trochanter, and femur brownish ferruginous to piceous, coxa and trochanter stramineous below; hind tibia fuscous, paler below; tarsus black, calcaria pale; wings hyaline, venation blackish, stigma pale at base.

Male.—More slender than female but otherwise very similar structurally; hind coxa and trochanter stramineous, hind femur somewhat paler; pale markings of abdomen larger, those of tergites 2–4 sometimes extending to base medially.

Host.—*Neodiprion tsugae* Middleton (probably secondary).

Type locality.—Sweet Home, Oreg.

Holotype, allotype, and *paratypes.*—U.S.N.M. no. 53346.

Paratypes.—Canadian National Collection; California Academy of Sciences.

Described from 50 females (including holotype) and 16 males (including allotype), all reared from cocoons of *Neodiprion tsugae* Middleton, undoubtedly as secondary parasites, partly at the type locality by R. L. Furniss, under Hopk. U. S. no. 31600G, and partly at the Northeastern Forest Insect Laboratory, New Haven, Conn., under no. 51–201–35, from cocoons of *N. tsugae* received from Sweet Home, Oreg.

Panargyrops areolaris, n. sp.

Closely related to *tibialis* Cushman, but generally stouter, with postpetiole nearly or quite twice as broad as petiole and second tergite much less than three times as long as basal width; clypeus nearly or quite as long as face is medially; propodeal areola very large, broader than long, with sides parallel; and ovipositor distinctly less than three-fourths as long as abdomen.

Female.—Length 6–8 mm (holotype 8 mm).

Head thick, occiput shallowly concave; temples hardly receding; diameter of lateral ocellus as long as postocellar line and half as long as ocellocular line; eyes parallel; face twice as broad as long, hardly longer medially than clypeus; malar space more than half as long as basal width of mandible; clypeal denticles distinct and rather widely separated; eyes somewhat bulging; antenna as long as abdomen, 29-jointed in holotype.

Thorax rather stout, much less than twice as long as deep, polished, very faintly punctate; pronotum not striate below, epomia distinct nearly to ventral angle; mesoscutum nearly circular, as broad as long; propodeal areola very large, slightly broader than long.

Abdomen slender, minutely punctate; postpetiole nearly twice as broad at apex as petiole, medially channeled; second tergite less than three times as long as basal width, third about as long as broad; ovipositor sheath little more than half as long as abdomen.

Black; pubescence with silvery reflection; scape below, mandibles, palpi, tegulae, and radices of wings white; humeral angle of pronotum pale reddish; legs reddish testaceous to ferruginous, hind leg darkest, front coxa and front and middle trochanters whitish, hind tibia mostly fuscous, its tarsus black, calcaria pale; abdomen with apical tergites very narrowly pale margined, venter whitish with piceous sternites.

Male.—Differs remarkably from female in both structure and color; eyes distinctly convergent below; face two-thirds as long as broad; malar space very short; abdomen very slender, postpetiole only a little broader than petiole, tergite 2 fully three times as long as basal width, its sides weakly divergent; tergite 3 much longer than broad; hind coxa and trochanter ventrally whitish; abdomen with a median pattern of reddish involving apex of tergite 1, apex or entire length of tergite 2, and entire lengths of 3 and 4, and broadening at apices of tergites 2–4 to embrace nearly or quite the entire width of the tergites, tergites 3–4 sometimes entirely reddish.

Host.—*Neodiprion tsugae* Middleton (probably secondary).

Type locality.—Sweet Home, Oreg.

Holotype, allotype, and *paratypes.*—U.S.N.M. No. 53347,

Paratypes.—Canadian National Collection; California Academy of Sciences.

Twenty-four females and 7 males, two of the females reared at the type locality by R. L. Furniss, September 16–17, 1935, under Hopk. no. 31660Q; the rest, including the holotype female and allotype male, reared from host cocoons from the same locality, at the Northeastern Forest Insect Laboratory, under no. 51–201–36–2 in Oct. 1936 and May and June 1937.

The antigeny in this species is very unusual—so far as the observation of the author goes, unique—for the genus. Also unusual is the frequent lack, especially in the male, of the second intercubital vein, resulting in an open areolet.

Delomerista diprionis, n. sp.

A stouter species than *novita* (Cresson), with the thorax nearly two-thirds as deep as long, the propodeal areola fully as broad as long, and the abdomen broader, with the second tergite not longer than its basal width. In *novita* the thorax is nearly twice as long as deep, the areola longer than broad, and the second tergite longer than the basal width. In *diprionis* the ovipositor sheath is hardly half as long as the abdomen and the apex of the ovipositor is very bluntly pointed, whereas in *novita* the sheath is distinctly more than half as long as the abdomen and the ovipositor is acute at the apex.

Female.—(Holotype) Length 10 mm, antenna 8 mm, ovipositor sheath 3 mm.

Head polished, sparsely and weakly punctate, except on face, which is coarsely punctate and mat, in dorsal view with temples convexly receding, about two-thirds as long as short diameter of eye; face medially strongly convex; clypeus about twice as broad as medially long; malar space nearly half as long as basal width of mandible.

Thorax stout, nearly two-thirds as deep as long, polished, sparsely and minutely punctate; propodeum short, posterior face longer than dorsal face, basal lateral areas and areola polished and at most sparsely punctate, posterior face finely coriaceous and mat, other areas more coarsely punctate.

Legs stout, hind coxa a little longer than deep, femur about four times as long as deep, tibia distinctly shorter than combined lengths of femur and trochanter.

Abdomen minutely ruguloso-coriaceous, mat, first tergite more roughly sculptured; broad, second tergite as broad at base as long; ovipositor sheath barely half as long as abdomen; ovipositor in profile bluntly pointed.

Color, as in *novita*, black, with mandibles, malar space, palpi, humeral angle of pronotum, tegulae, radices of wings, and membranous margins of tergites 5–7 whitish; clypeus and occasionally facial orbits piceous; legs ferruginous; apex of front coxa, trochanter and femur anteriorly and apically, middle trochanter and femur apically, front and middle tibiae, except a basally incomplete piceous streak on the extensor surface of each, hind tibia at base and usually more or less below, and a narrow basal annulus on basitarsus whitish; front coxa piceous; front and middle tarsi fuscous; hind femur at apex, and hind tibia and tarsus except white markings, black; wings hyaline, venation black, stigma with a small white spot at base; apex of ovipositor sheath reddish.

Male.—Except for smaller size, more slender build, and shorter malar space, differs from female largely in greater extent of white, this including face, underside of scape, clypeus, entire front and middle coxae and trochanters and hind trochanter, and front and middle femora except posteriorly.

Host.—Various species of *Diprion* and *Neodiprion.*

Type locality.—Oakville, Ontario.

Holotype, allotype, and *paratypes.*—U.S.N.M. no. 19180.

Paratypes.—Canadian National Collection; Boston Society of Natural History; Connecticut Agricultural Experiment Station; Entomological Laboratory, Maine Forest Service, Augusta, Maine; California Academy of Sciences.

Described from 38 females and 27 males selected from several series reared from various species of the sawfly genera *Diprion* and *Neodiprion* and a few collected specimens as follows: 9♀ and 4♂, Oakville, Ontario, reared, evidently indoors, January 1–19, 1934, from *Diprion simile* (Hartig), including holotype and allotype: 3♀ and 6♂, New Haven, Conn., reared

April 29–May 21 from *D. simile* by M. P. Zappe; 1 ♀, Dublin, N. H., reared (indoors) January 15, 1938, from *D. polytonum* (Hartig) under N. E. Forest Insect Laboratory no. 11.203–37–22; 5 ♀ and 10 ♂, Sweet Home, Oreg., under N. E. For. Ins. Lab. no. 51–201, April 14–June 21, 1936, from *Neodiprion tsugae* Middleton; 4 ♀ and 3 ♂, Sweet Home, Oreg., June 29–July 19, 1935, also from *Neodiprion tsugae* Middleton, under Hopk. no. 31607 P; 2 ♀ and 1 ♂ from the same host, Queen Charlotte Island, British Columbia, April 6, 1931, and March 21 and April 26, 1932, G. R. Hopping; 8 ♀ and 2 ♂, Lincoln, Maine, May 26–June 5, 1932, from *Neodiprion* sp. on *Pinus rigida* and *Pinus resinosa;* 1 ♀, Mont. Laurier, Quebec, December 6, 1929, *Neodiprion* sp. on *Pinus banksiana*, M. Dunn; 1 ♀, Pictured Rocks, Munising, Mich., August 2, 1936, C. W. Sabrosky; 3 ♀, Cranmoor, Wis., June 25, 1910, C. W. Hooker; 1 ♀, Pullman, Wash., August 11, 1896, C. V. Piper; 1 ♂, Moscow, Idaho, May 30, 1912, J. M. Aldrich.

There is considerable variation in size, partly associated with size of the host, specimens from *Diprion simile* averaging largest and those from *Neodiprion tsugae* smallest, females ranging in length from 5 to 11 mm, and males from 6 to 10 mm. The comparative width of the abdomen, especially in the female, and the strength of the propodeal carinae also exhibit considerable variation.

Genus **Lamachus** Foerster

To this genus are here assigned those species, otherwise very close to *Mesoleius* both morphologically and biologically, that possess the alar areolet and have the clypeus without a median elevation, but nearly flat, at most shallowly emarginate apically and with a narrow reflexed margin. All the species here treated differ from the genotype, *lophyrorum* (Hartig), by having the speculum more or less polished. Like the genotype, all are parasitic in larvae of sawflies of the subfamily Diprioninae.

The following North American species are referable to the genus as here limited:

Lamachus lophyri (Ashmead), n. comb.

Neoeryma lophyri Ashmead, Proc. Ent. Soc. Washington **4:** 169. 1897.

Lamachus virginianus (Rohwer), n. comb.

Lagarotis virginianus Rohwer, Proc. U. S. Nat. Mus. **49:** 218. 1915.

Lamachus ruficornis (Cushman), n. comb.

Labrossyta ruficoxalis Cushman, Proc. Ent. Soc. Washington **21:** 118. 1919.

Lamachus contortionis Davis

Lamachus ? *contortionis* Davis, Trans. Amer. Ent. Soc. **24:** 284. 1897.
Lagarotis diprioni Rohwer, Proc. U. S. Nat. Mus. **49:** 215. 1915. New synonymy.

Lamachus tsugae, n. sp.

A black species with unusually few and small pale markings.

Female.—Length (holotype) 6 mm, antenna 5.5 mm.

Head mat, alutaceous, only temples shining; temples strongly convex; postocellar line little longer than ocellocular line and hardly a half longer than diameter of an ocellus; face sparsely and finely punctate, nearly as broad as eye is long; eyes parallel, very faintly emarginate opposite antennae; clypeus fully half as long as interfoveal line; malar space much less than half as long as basal width of mandible; antenna 35-jointed.

Thorax stout, hardly a half longer than deep, finely alutaceous and sparsely punctate laterally and ventrally, subpolished and sparsely punctate dorsally, speculum polished; notaulices shallow but distinct to a flattened area on disk of mesoscutum; propodeum finely alutaceous, shining basally, mat apically, with faintly indicated lateral carinae, but without median and apical carinae; legs rather slender, hind femur nearly six times as long as deep.

Abdomen stout, tergite 1 distinctly broader at apex than distance from spiracle to apex and more than half as broad basally as apically, tergite 2 broader at base than long; abdomen alutaceous, mat, impunctate, compressed at apex.

Black, with the following markings yellow: Triangular spots in lower facial orbits and occasionally more or less of middle area of face, clypeus, cheeks narrowly, mouthparts, collar narrowly and more or less of lower anterior margin and humeral angle of pronotum, sometimes small spots at origins of notaulices, usually very narrow margins of tergites, and ventral plica; antenna black, faintly reddish below; scutellum and postscutellum sometimes piceous and rarely yellowish medially; legs ferruginous, front and middle coxae and trochanters usually more or less stramineous anteriorly, hind knee, apical third or more of tibia, and entire tarsus black, tibia basally white; wings hyaline, venation black, stigma slightly paler.

Male.—More slender than female but otherwise very similar structurally; face yellow for its entire width and nearly up to antennal foramina, upper margin of yellow made uneven by three points of black extending into it from above; prepectus medially yellow and sometimes one or more streaks of yellow extend backward from it on sternum and lower part of pleurum.

Host.—*Neodiprion tsugae* Middleton.

Type locality.—Sweet Home, Oreg.

Holotype, allotype, and *paratypes.*—U.S.N.M. no. 53348.

Paratypes.—Canadian National Collection; California Academy of Sciences.

Described from 19 females and 7 males, all from cocoons of the host collected by R. L. Furniss at the type locality but mostly reared at the Northeastern Forest Insect Laboratory under no. 51.201.36.2. A few were reared by the collector under Hopkins U. S. no. 31607T.

Lamachus oregon, n. sp.

Similar to *ruficoxalis* (Cushman), but with entire face, broad frontal orbits, mesosternum largely, and front and middle coxae and trochanters yellow.

Female.—Length 7.0 mm, antennae (broken).

Head alutaceous, mat, temples somewhat shining, moderately convex and receding; postocellar line and diameter of an ocellus equal, slightly shorter than ocellocular line; face medially sparsely punctate, hardly as broad as eye is long; eyes parallel, faintly emarginate; clypeus half as long as interfoveal line; malar space nearly half as long as basal width of mandible.

Thorax hardly a half longer than deep, finely alutaceous and weakly shining laterally, polished dorsally, speculum polished, mesoscutum very finely, pleura more coarsely, punctate; notaulices faint; propodeum finely, granularly mat medially and apically, basal lateral areas somewhat shining and shallowly punctate; only lateral carinae distinct; legs moderately stout, hind femur less than six times as long as deep.

Abdomen rather slender; first tergite less than half as broad basally as apically and hardly broader at apex than distance from spiracles to apex, with a median sulcus on postpetiole flanked by prominent, posteriorly divergent ridges; tergite 2 hardly as broad at base as long; abdomen alutaceous and almost mat, impunctate, compressed apically.

Head and thorax black and yellow, abdomen and legs largely ferruginous; yellow are the face, broad frontal orbits, cheeks and malar space, clypeus, mandibles, palpi, underside of scape and pedicel, anterior margin and humeral angles of pronotum, large cuneiform spots on mesoscutum, scutellum largely, postscutellum, tegulae, subalar tubercles, posterior margin of prepectus, mesosternum largely, mesometapleural suture, front and middle coxae and trochanters and the extensor surfaces of their tibiae, basal half of hind tibia, and ventral plica including hypopygium; tergite 1 black, with broad apical margin extending laterally to include spiracles ferruginous, median carinae near base yellowish; apical half of hind tibia and its tarsus black; flagellum black above, reddish below; wings hyaline, venation black.

Male.—Similar to female, but malar space shorter, postocellar line longer than ocellocular line or than diameter of ocellus, the latter two equal, abdomen more slender; yellow markings, especially on thorax, more extensive, with pronotum largely, mesosternum, prepectus and lower half or more of mesopleuron, metapleuron largely, and sometimes part of pleural area of propodeum yellow; mesoscutal markings frequently extending backward along notaulices and meeting on disk; black of thorax and abdomen frequently more or less, and sometimes entirely, replaced by ferruginous. Antenna with 35–36 joints.

Host.—*Neodiprion tsugae* Middleton.

Type locality.—Sweet Home, Oreg.

Holotype, allotype, and *paratypes.*—U.S.N.M. no. 53349.

Paratypes.—Canadian National Collection; California Academy of Sciences.

One female and 16 males, all reared at the Northeastern Forest Insect Laboratory from cocoons of the host collected at the type locality, under nos. 51.201.36.2 (June 14, 1937) and 51.201.35 (June 17, 1936). The holotype female and allotype male are selected from the first-mentioned series.

The males vary greatly in color, as stated above, and from 4 to 8 mm in length.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

NEW MEMBERS ELECTED

The following were recently elected to active resident membership in the Academy:

Harry G. Barber, associate entomologist, U. S. Bureau of Entomology and Plant Quarantine, in recognition of his work on the taxonomy and biology of the Hemiptera.

Luther A. Black, professor of bacteriology, University of Maryland, in recognition of his researches in dairy and food bacteriology, especially the physiology of bacteria and thermophilic bacteria.

Juan Brewer Demaree, senior pathologist, U. S. Bureau of Plant Industry, in recognition of his contributions on the diseases of nut trees and small fruits.

William W. Diehl, associate mycologist, U. S. Bureau of Plant Industry, in recognition of his work on the taxonomy of fungi, particularly the Ascomycetes.

Adolph Eichhorn, superintendent in charge, Animal Disease Station, U. S. Bureau of Animal Industry, Beltsville, Md., in recognition of his contributions to veterinary science and comparative pathology.

Chester W. Emmons, senior mycologist, National Institute of Health, in recognition of his contributions to systematic mycology and in particular his researches on fungi pathogenic to man.

Ira N. Gabrielson, chief, U. S. Bureau of Biological Survey, in recognition of his accomplishments in biological research, especially his work on the distribution and economic importance of birds and rodents.

Anna E. Jenkins, associate mycologist, U. S. Bureau of Plant Industry, in recognition of her contributions to taxonomic mycology and in particular her researches on the orders Myriangiales and Exoascales.

Edmund B. Lambert, pathologist, U. S. Bureau of Plant Industry, in recognition of his work on the culture and diseases of mushrooms.

Hans Lineweaver, chemist, U. S. Bureau of Agricultural Chemistry and Engineering, in recognition of his work in biochemistry.

John H. Martin, senior agronomist, U. S. Bureau of Plant Industry, in recognition of his investigations in the genetics of sorghum.

John B. Mertie, jr., senior geologist, U. S. Geological Survey, in recognition of his work on the geology of Alaska.

Mark L. Nichols, acting chief, Division of Research, U. S. Soil Conservation Service, in recognition of his researches in soil physics relating to tillage machinery and his contributions to improved soil conservation practice.

Dorothy Nickerson, color technologist, U. S. Bureau of Agricultural Economics, in recognition of her contributions to optics, particularly to the colorimetric grading of agricultural products.

Francis Wilton Reichelderfer, chief, U. S. Weather Bureau, in recognition of his work on the development of aeronautical meteorology and air mass analysis.

John A. Scherrer, chemist, National Bureau of Standards, in recognition of his work on the development of methods in the chemical analysis of nonferrous materials.

JOSEPH F. SILER, director, Army Medical School, in recognition of his achievements in the fields of sanitation and hygiene, and particularly for his work on the transmission of dengue fever and the prevention of typhoid fever.

MAURICE I. SMITH, principal pharmacologist, National Institute of Health, in recognition of his researches in drug and vitamin standardization, particularly his contributions on the pharmacology of phenol esters and the toxicology of selenium.

EARLE O. WHITTIER, senior chemist, U. S. Bureau of Dairy Industry, in recognition of his researches on the chemistry of milk, particularly its buffer action.

The following were recently elected to active nonresident membership in the Academy:

WALTER J. YOUNG, head of the Department of Psychology and Philosophy, Mary Washington College, Fredericksburg, Va., in recognition of his researches in psychology, philosophy, and education.

The following were recently elected to honorary membership in the Academy:

GEORGES PERRIER, Major General Retired, formerly chief, Division of Geodesy of the French Army, Paris, France, in recognition of his contributions in the field of geodesy.

PEDRO SANCHEZ, director, Pan American Institute of Geography and History, Tacubya, D. F., Mexico, in recognition of his cooperation with the United States Government in the field of geodesy.

EDWARD RHODES STITT, Rear Admiral, U. S. Navy (retired), Washington, D. C., in recognition of his achievements in the fields of bacteriology and animal parasitology and particularly his contributions to tropical medicine.

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JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

Vol. 29 October 15, 1939 No. 10

GEOCHEMISTRY.—*The radium content of an ocean-bottom core.*[1]

C. S. Piggot and W. D. Urry, Geophysical Laboratory, Carnegie Institution of Washington.

The data in the literature on the radium content of ocean-bottom sediments have been summarized by C. S. Piggot in connection with the presentation of the radium determinations made by him on 28 samples secured by the *Carnegie* on her last cruise.[2] With two or three exceptions, all the samples, including the *Carnegie* suite, were obtained from the surface of the ocean bottom or at a depth of only a few centimeters. It is obvious that a detailed radioactive study of material extending to greater depths is necessary in order to discover the mechanism by which the high concentration of radium was produced and in order to evaluate its geological significance.

The apparatus to secure core samples from the ocean bottom, developed primarily to fill this demand, has been fully described in previous publications.[3] Several cores obtained with this apparatus have been examined lithologically and chemically in detail,[4] so that they can now be sampled for radium determinations in such a manner as to facilitate the interpretation of the results.

DESCRIPTION OF THE CORE

A radium analysis of core No. 3, which was obtained by Piggot aboard the Western Union Cable Ship *Lord Kelvin* in 1936, has now been completed. The core was taken at a position roughly east of Halifax, Nova Scotia, off the Newfoundland Banks, and is 2.85 meters long.[5] It differs entirely from the rest of the suite taken across the Atlantic Ocean in exhibiting no characteristic alternating zones of sediments deposited in warm and in cold water. The volcanic shards are scarce throughout the length of the core and show little

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[1] Received September 20, 1939.

[2] Piggot, C. S. Amer. Journ. Sci. **25**: 229. 1933.

[3] Piggot, C. S. Bull. Geol. Soc. Amer. **47**: 675. 1936; Proc. Amer. Phil. Soc. **79**: 35. 1938.

[4] This examination of the Atlantic suite of cores has been carried out by the U. S. Geological Survey. U. S. Geol. Surv. Prof. Paper. (In Press.)

[5] Piggot, C. S. *Core samples of the Ocean-bottom and their significance.* Sci. Monthly **47**: 201. 1938.

to no variation in concentration.[6] Core No. 3, in all its major aspects, is of very uniform composition both lithologically and chemically. It consists of roughly 50 percent calcium carbonate and 50 percent clay and silt and exhibits a somewhat higher clay content in three places, although the only major departure from uniformity is a thin band of silt at about 15 cm from the bottom.[7]

METHOD OF RADIUM DETERMINATION

The radium is determined by measuring the ionization current due to the disintegration of the radon in equilibrium with the radium and comparing it with the ionization current sustained by the radon from a known amount of radium. Recent developments in the technique of this method are discussed by Urry.[8] The present apparatus, which was constructed for obtaining precision, convenience, and speed in the radium determinations, with samples as small as 1 gram in weight, contains a compensating chamber system as described by Urry but differs in several important respects from the earlier apparatus. It will be fully described in a subsequent paper. The ionization current is recorded automatically by the use of a Lutz electrometer operating in the second manner of measurement previously described.[9] The laborious chemical method,[10] formerly used for obtaining the equilibrium amount of the radon—which is necessary when measuring other quantities on the same sample—has been replaced by the fusion-furnace method developed by R. D. Evans.[11] The crushed or powdered specimen is heated to about 2,000°C., thus releasing all the radon. The solid samples from the core were scraped on all sides to a depth of 1 to 3 mm and finely powdered with no separation by sieves or tabling. It is, of course, important to insure that there is no diffusion of the radon out of the specimen prior to the heating. The results in Table 1 indicate a loss of radon when the samples are left exposed to the atmosphere for 30 days after powdering. Hence the powdered core specimens were stored for this period in sealed glass tubes and the radon from the gas phase added to that obtained from the fusion of the powder. Prior to sealing, the specimens, except where otherwise stated, were heated to 600°C. in a stream of radon-free nitrogen for one hour.

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[6] U. S. Geological Survey. *Op. cit.*

[7] U. S. Geological Survey. *Op. cit.*

[8] Urry, W. D. *Determination of the radium content of rocks.* Journ. Chem. Phys. **4**: 40. 1936.

[9] Urry, W. D. *Op. cit.*, p. 43.

[10] Urry, W. D. *Determination of the thorium content of rocks.* Journ. Chem. Phys. **4**: 34. 1936; see p. 36.

[11] Evans, R. D. Rev. Sci. Instr. **4**: 223. 1933.

RESULTS

The results in Table 1 are expressed on an air-dried basis. Judging by the 17 calcium-carbonate analyses at various depths, reduction to a carbonate-free basis would change but little the relative variations in Table 1. Nevertheless, for more complex cores it is expedient to make CO_2 and "water minus" analyses for each sample investigated, the "water minus" being determined on the actual sample taken. The present results are based on a standard radium solution prepared by the Denver Fire Clay Co., standardized by S. C. Lind and used by Piggot in former radium determinations. It is planned to base the results finally on a radium standard now in the course of preparation by the Bureau of Standards. Any change in the calibration constant of the apparatus will affect only the absolute and not the relative values given here.

TABLE 1.—THE RADIUM CONTENT OF AN OCEAN-BOTTOM CORE

Core No. 3 = P-124. Depth of water 4,700 meters.
Latitude 46°03′O″ N. Longitude 43°23′O″ W.

Specimen No.	Depth	Radium in 10^{-12} gram per gram
	cm	
P-124-0	0–2	1.21 ± .015
		(1.06 .020)**
P-124-25	25–28	1.15 .012
P-124-74*	74–77	1.24 .016
P-124-130	130–134	1.76 .026
P-124-207	207–211	1.85 .020
		(1.22 .023)**
P-124-283*	283–285	1.45 .015
P-124-268 (silt)	268–270	0.79 .008

* Somewhat higher clay content.

** Samples taken from the same powdered specimen, stored for 30 days after powdering, but not sealed.

DISCUSSION

Any discussion of these results must, at present, pertain only to this specific core. If one rightly excludes the silt result, the reason for which is given later, two points of major interest are:

A. The radium content does not diminish with depth in the core.

B. The radium content, on an air-dried basis, is close to the general run of the radium content of granites. (The average radium content of four groups of Finnish granites is *ca.* 1.6 by 10^{-12} grams Ra per gram.)[12]

Since the core apparently failed to reach the first glacial zone which

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[12] PIGGOT, C. S. Amer. Journ. Sci. **35A**: 227. 1938.

was reached in 29 cm at the next station, No. 4,[13] it can not very well represent a period greatly in excess of a few thousands of years. In such a short period the presence or absence of uranium I and its isotope uranium II has no measurable effect on the radium. The variation of radium with depth in the core, if there is a constant source at the surface of the ocean bottom, is controlled by ionium, which is the immediate parent of radium. Were ionium to be completely absent, the radium content would diminish with time, as shown in Fig. 1 (curve I). The 285 cm core can hardly represent less than 2,000 years, which is greater than the half life of radium (*ca.* 1,600 years). If half the equilibrium ionium amount corresponding to the radium

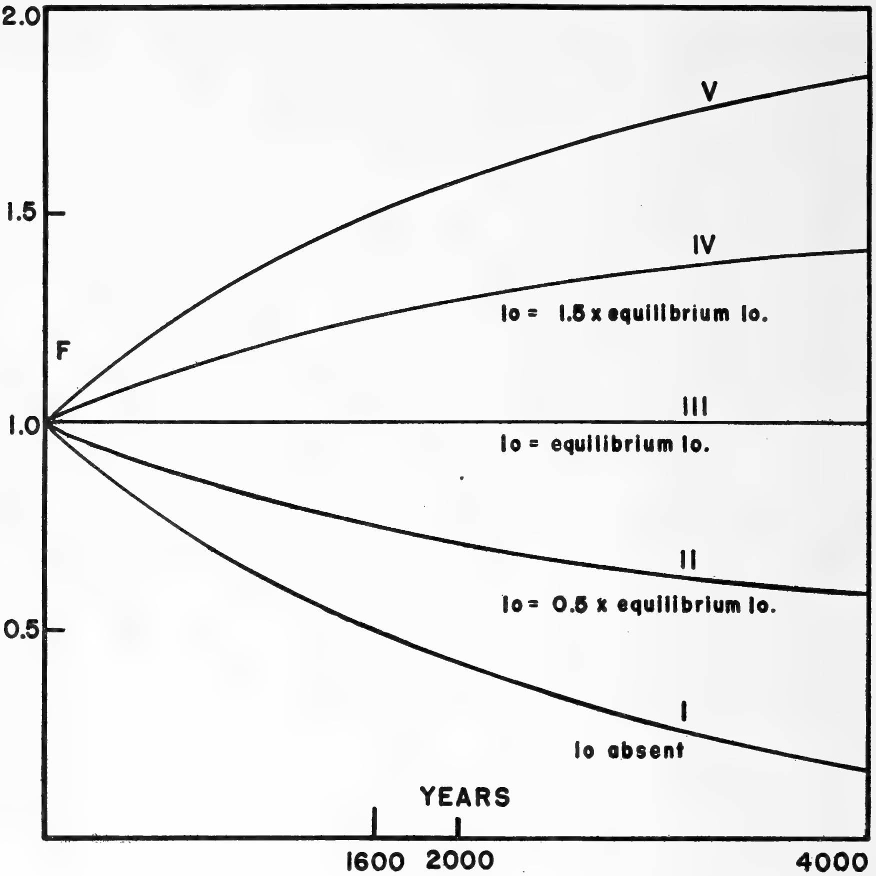

Fig. 1.—The fraction *F* of the radium content at the top of the core (surface of the ocean bottom) to be expected at a depth in the core representing a given time, under various assumptions regarding the state of radioactive equilibrium between ionium and radium.

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[13] U. S. Geological Survey. *Op. cit.*

at the surface of the bottom were present, we still would have a measurable decrease in radium with depth (curve II). If ionium and radium were deposited in equilibrium, the radium content would be constant if uranium is present (curve III) and practically constant even if uranium is absent. An excess of ionium over the equilibrium amount would yield an increasing radium content (curve IV).

A constant radium content at the present time, as is exhibited particularly in the first 77 cm of this core, would be possible even with a complete or partial absence of ionium, provided that there was a decreasing deposition of radium with time in the past following curve V or the corresponding complement of some such curve as II. Since this is entirely improbable, the original assumption of a roughly constant source of radium at the surface of the bottom is not without foundation.

Ionium, an isotope of thorium, is so different from radium in its chemical properties that a purely chemical deposition requiring approximately the amounts in radioactive equilibrium to be deposited by independent chemical processes seems unlikely in this case.

The narrow band of silt near the bottom of the core gives a result more nearly comparable with the continental sediments. There is some evidence that its origin may be due to submarine slumping.[14] It appears to be wholly foreign to the conditions of formation of the rest of the core.

In addition to a systematic examination of the radium content of the Atlantic cores, experiments are in progress to determine uranium, thorium, and ionium independently in these cores.

SUMMARY

The development of the new ocean-bottom sampler has made available a number of cores, one of the objects of the apparatus being to probe below the ocean-bottom surface and to determine the radioactive relationship between the ocean troughs and the continents.

One of the Atlantic cores is extremely uniform in composition both chemically and lithologically and was chosen as the most suitable core to examine preliminarily in order to ascertain, if possible, the radioactive equilibrium relations before proceeding to the more complex cores exhibiting wider variations in composition.

Determination of the radium content at various depths in the core shows: (A) no decrease in the radium content with depth; (B) a radium content corresponding approximately to that of the granites.

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[14] U. S. Geological Survey. *Op. cit.*

The conclusions based on this exploratory investigation, which must be limited to this particular core, are: (1) that, with regard to the length of time here represented, the presence or absence of uranium has no bearing on the radium content; (2) that the ionium is probably present in an amount corresponding roughly to radioactive equilibrium with the radium; and (3) that in view of the widely different chemical properties of ionium (thorium) and radium, chemical deposition plays no role in the radioactivity of this particular core. This does not exclude the possibility that chemical deposition may be important in other instances.

PHYSICS.—*An instrument for the reproduction, regulation, and control of variable temperature.*[1,2]

W. E. STONE,[3] U. S. Bureau of Entomology and Plant Quarantine. (Communicated by C. F. W. Muesebeck.)

One of the most important considerations in research on insect and other pests is the factor of temperature, especially in relation to the possibility of survival and of establishment outside the present limits of distribution. The need to determine experimentally in Mexico the possible range of distribution in the United States of the Mexican fruitfly [*Anastrepha ludens* (Loew)] and related species, as conditioned by temperature, led to the invention and development of an instrument for the laboratory reproduction of field temperatures as recorded by thermographs.

DESCRIPTION

The essential details of the construction are shown in Fig. 1. The motivating unit consists of a clock-driven cylinder *A*, *a*, of the type in general use on thermographs and mounted in the same manner on a base *b*. A temperature pattern *c* cut from fiberboard is fastened to the cylinder like a thermograph chart by a flexible metal band *d*.

The regulating unit is mounted on a vertical shaft *e*, which supports a movable stage *f*, adjustably fixed by means of a collar and setscrew. Two pairs of vertical brackets *B*, *a*, *a*, and *b*, *b*, are placed at the ends of the movable stage. Only one of each pair appears in the side ele-

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[1] Received April 17, 1939.

[2] Application for public-service patent pending.

[3] The author wishes to express his appreciation to Dr. A. C. Baker, chief of the Division of Fruitfly Investigations, for helpful suggestions during the development of the instrument especially with regard to the elimination of gears to reduce play and the use of fiberboard for chart patterns; to Mr. Juan Ramirez, of the same division, for making drawings of the instrument; and to Mr. Albert J. Kramer, of the Solicitor's Office of the Department of Agriculture, from whose draft of the formal patent application much of the present description has been taken.

vational view *A*, *g* and *h*. The brackets *a*, *a* support an adjustable tracing arm *A*, *i*, fulcrumed between them on a threaded horizontal shaft by means of simple point and socket bearings. The arm is laterally adjustable on the threaded horizontal bar and adjustable in length, being composed of two parts fitted together with a slot and two setscrews. At the outer end of the tracing arm a tracing point of steel wire is attached by means of a connecting wrist and is designed to follow the contour of the chart pattern. Near the outer end the arm is slightly twisted and bent toward the cylinder so that the tracing point, in following the contour of the temperature pattern, is not interfered with by the peaks. In a manner similar to that of the tracing arm, a lever *j* is fulcrumed between the brackets *B*, *b*, *b*. The longer arm of the lever extends upward and is joined to a segmental arc *A*, *k*, of approximately 115 degrees. At the upper end of the segmental arc a wire *l* is attached; preferably No. 37 insulated copper magneto wire should be used. The wire rests in a fine groove extending the entire length of the arc segment in the middle of its periphery. A weighted, platinum-pointed contact drop *m* is suspended from the lower end of the wire and extends to a toluene-mercury thermostat *n*. An insulator of hard composition board or other suitable insulating

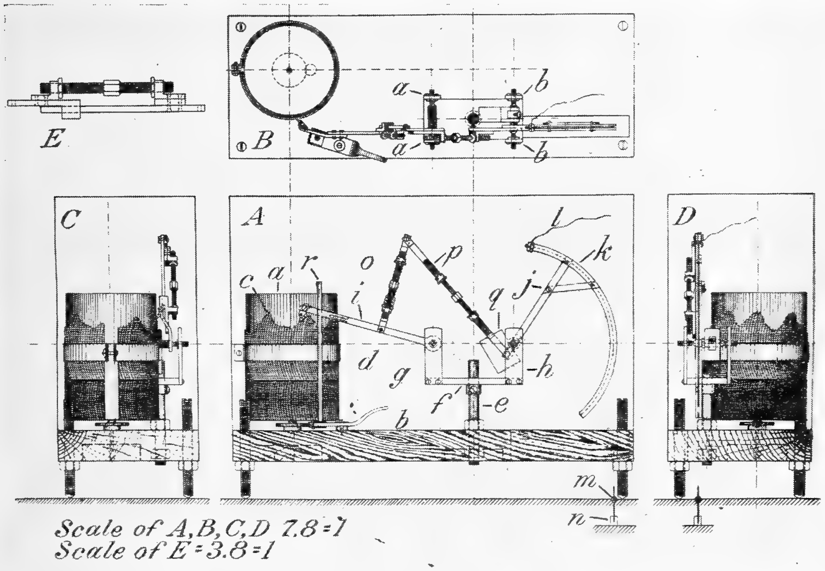

Fig. 1.—Essential details of construction of an instrument for the reproduction, regulation, and control of variable temperature: *A*, side elevational view; *B*, a plan view; *C* and *D*, end views.

material is fixed at the lower end of the drop about an inch from the point. The tracing arm and lever are mechanically linked by means of a main adjustment rod *o* and a minor adjustment rod *p*. The major adjustment rod is shown in greater detail in Fig. 1, *E*. One end of the major adjustment rod is fixed at right angles to the tracing arm at a point between its ends, the free end being pivoted to one end of the minor adjustment rod. The other end of the minor adjustment rod is pivoted to the short arm of the lever *j* substantially as shown in the drawings. Both rods are adjustable in length by means of threaded spacers set in threaded sockets. One-half of each of the spacers is threaded in one direction and the other half, in the opposite direction. In order to balance this instrument delicately, a counterweight *q* is adjustably mounted on the bearing shaft of the lever *j* by means of a collar and setscrew. A vertical guide bar *r* is fixed to a lever with a handle and is pivotally mounted at the base of the instrument near the cylinder. The guide bar holds the point of the tracer arm in proper operating position with respect to the fiberboard pattern. Threaded legs at the four corners of the base are provided for the purpose of making placement adjustments for the instrument.

PREPARATION OF CHART PATTERNS

In the preparation of a chart pattern for the reproduction of daily or weekly recorded temperatures, a heliographic copy of the original thermograph chart is made. A clearer print will be obtained if the temperature record is inked with black India ink and the chart treated with a preparation to make it translucent. Light, colorless lubricating oils will serve the purpose if standard preparations are not available. Printing with a treated chart requires approximately one-tenth of the time needed for an untreated chart. When the print is dry, it is glued or pasted on fiberboard 1 mm or slightly less in thickness with the back toward the board. The contour of the temperature record is then cut as accurately as possible with shears, and the finishing is done with an assortment of files. A graphite pencil should be run over the contour to facilitate the movement of the tracing point. The cutting of a chart pattern of a weekly temperature record requires about 20 minutes. Patterns of daily temperature records can be cut in considerably less time.

Patterns of gradually rising or falling temperatures, which are plotted in the form of a straight line or of gradually increasing or decreasing rising or falling temperature plotted in the form of a curve, may be cut quickly with a sharp knife.

In fastening the chart to the clock cylinder a better fit will be obtained if the pattern is held for a short time over a vessel of boiling water.

ADJUSTMENT AND OPERATION

After the preparation and placing of the chart pattern, the instrument is adjusted for the particular type of pattern. The initial adjustment consists in lengthening or shortening the tracing arm so that the arc described by the tracing point is of the same radius as the temperature arcs on the chart pattern. The movable stage is then raised or lowered until the arc of the tracing point, when in motion, exactly coincides with the arcs of the chart pattern at a point on the front and near the center of the pattern.

The major adjustment rod is then lengthened or shortened until the distance traversed by the contact drop, as a result of the movement of the tracer point through a given number of degrees on the pattern, is equivalent to the change in the thermostat for an equal number of degrees. The minor adjustment rod is then lengthened or shortened to rectify the position of the arc segment so that the maximum range of operation may be maintained under all adjustments.

The clock is regulated to rotate the cylinder slightly faster than the recorder to allow for the difference caused by the thickness of the fiberboard of the pattern.

When the instrument is once adjusted for a particular type of chart pattern, it will operate indefinitely without further adjustment.

In operation the tracing point rests on the top edge of the fiberboard pattern, and as the cylinder rotates it follows the contour of the pattern, raising or lowering the tracing arm. The tracing arm actuates the adjustment rods, which, in turn, actuate the arc segment. Thus the drop contact is raised or lowered in the thermostat tube, with the movement of the tracing point cutting on or off the heat by means of an ordinary electric relay connected through the thermostat and the wire extending from the upper end of the arc segment.

THERMOSTAT

A glass mercury-toluene thermostat made of 50 inches of 6/16-inch bore tubing, with an 8-inch neck of 3/16-inch bore tubing fused together and bent into a convenient form, has proved to be a good size for use with this instrument. A thermostat of this size used intermittently for 3 years has shown no apparent change in volume during that time.

When the mercury column recedes in the thermostat with a decreasing temperature, a thin film of mercury may be left on the wall of the tube for some time. As the contact drop is necessarily freehanging, the point would at times make contact with the film causing the relay to operate prematurely, except for the insulator near the end of the drop, which keeps the point away from the film.

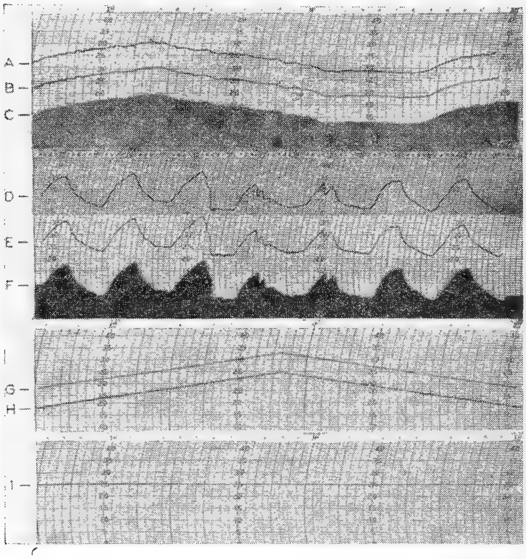

Fig. 2.—Photograph of original thermograph charts (*A*, *D*), chart patterns (*C*, *F*, *H*), records of temperature reproductions (*B*, *E*), and records of a produced gradually rising and falling temperature (*G*) and constant temperature (*I*).

There is no reason why other types of thermostats than mercury-toluene cannot be used with this instrument if they possess the necessary range.

TEMPERATURE CABINETS

Standard well-insulated temperature cabinets can not be used with this instrument when producing or reproducing highly variable temperatures unless they are equipped with cooling coils, because cooling is too slow. The need for a rapid heat exchange to obtain variable temperatures necessitates considerably larger heating elements to reach high temperatures than in constant-temperature apparatus. Air circulation must be such that the thermostat is completely enveloped in the moving air stream.

ACCURACY

The accuracy obtained in the operation of this instrument may be seen from the photograph of the charts shown in Fig. 2. *A* is an original daily thermograph record, May 28, 1933, from Cuernavaca, State of Morelos, Mexico. *B* is a record of the reproduction of the temperature made in a cabinet at Mexico City from the chart pattern *C*. The upper part of the chart *B* has been trimmed to allow a closer comparison of the original and the reproduced temperature. An original record of a weekly temperature, June 29 to July 6, 1936, at Santa Engracia, State of Tamaulipas, Mexico, is shown in *D*. The record of the reproduced temperature, *E*, made from the chart pattern *F*, shows the accuracy with which weekly temperature records can be reproduced in the laboratory. *G* is a record of a gradually rising and falling temperature made from the chart pattern *H*. *I* is a constant-temperature record which was obtained by stopping the clock of the instrument.

SUMMARY

An instrument has been developed to permit the laboratory reproduction of field-recorded temperatures in experiments at Mexico City to determine the possible range of distribution of the Mexican fruitfly and related species in the United States. A description of the instrument showing the essential details of construction is given.

The method of preparation of the chart patterns, showing the different steps in the operation and the time consumed, and the methods of making adjustments and of operation are discussed.

A mercury-toluene thermostat made of 50 inches of 6/16-inch bore tubing with a neck of 3/16-inch bore tubing has been used with the instrument intermittently for 3 years without apparent change in volume.

Standard well-insulated temperature cabinets can not be used with the instrument when producing or reproducing highly variable temperatures unless they are equipped with cooling coils, because cooling is too slow.

The accuracy obtained in operation is shown in a photograph of charts of reproductions of daily and weekly temperature records and of the production of a gradually increasing and decreasing temperature as well as a constant temperature.

PHYSICAL CHEMISTRY.—*The assignment of uncertainties to the data of chemistry and physics, with specific recommendations for thermochemistry.*[1]

FREDERICK D. ROSSINI, National Bureau of Standards, and W. EDWARDS DEMING, U. S. Department of Agriculture.

CONTENTS

I. INTRODUCTION

In order that the results of measurements made in different laboratories may be compared and appraised for the purpose of estimating the uncertainty or confidence interval to be attached to the published value of a physical or chemical constant, it is desirable that experimenters adopt a uniform procedure for expressing the consistency of their data, or be explicit in their statements regarding such consistency. Anyone to whom the experimental details and the original numerical data are available can form his own opinions by whatever method he likes, but since full details are often too extensive for publication, understanding among workers in different laboratories and in different countries will be promoted if all the investigators in any field will be careful to give the information that is essential for evaluating the consistencies of their final values. The purpose of this paper is to present some discussion on this subject and to offer some specific recommendations in connection with the experimental data of thermochemistry.

Precision and accuracy are terms invented for convenience in discussing errors of observation, uncertainties, and related matters. The precision of a set of observations is measured by the consistency or internal agreement reached as the series is extended under controlled conditions. Precision measures the ability of an investigator to repro-

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[1] Received August 26, 1939. The numbers in brackets throughout the text indicate the references at the end of the paper.

duce his observations. If they fluctuate widely, his precision is low; but if they fluctuate within a narrower range, his precision is higher.

In contrast to precision and internal agreement, accuracy is related to the discrepancy between the mean of a set of observations and the true but "unknown" value of whatever quantity is being measured. A piece of experimentation may be at once extremely precise yet hopelessly inaccurate because of constant or systematic errors, unpredictable or even unsuspected. There are three ways of going about the problem of discovering the existence of constant or systematic errors: first, by investigating the physical principles involved in the action of the apparatus; second, by ascertaining whether there exists any unnatural trend of the final values with any one of the variables involved in the measurements; and third, by comparing the results obtained in different laboratories. Incompatible discrepancies between the results obtained by two different laboratories may convince one that constant errors are present in the work of one or both of them, but the actual recognition of the errors must be made by an investigation of the principles of the measurements. It is of course possible, by accident, for the means of two sets of experiments to be in good agreement even though one or both sets are afflicted with systematic errors. Moreover, if the number of experiments is small, the two sets of data may be in disagreement and yet free from constant errors; poor agreement merely suggests but does not prove the presence of constant errors.

In speaking of incompatible discrepancies between two sets of observations supposed to measure the same quantity, one must have in mind some measure of internal consistency for the two sets of observations and some way of comparing these internal consistencies with the difference between the means from the two sets. The important consideration is not how large the discrepancy is, but rather how the discrepancy compares in magnitude with the internal consistencies of the two sets of data. Statisticians have set up mathematical models for calculating odds against discrepancies between two means exceeding different multiples of a certain function of the measure of uncertainty of the two sets of observations, and these odds will be correct if the experiments fit the assumptions on which the calculations are based. The existence of this concordance between experiments and assumptions is difficult to ascertain in actual physical and chemical experimentation, because any one series of observations is rarely extended long enough to be compared with the mathematical model (cf. Shewhart [9]). Nevertheless, probability considerations are helpful on the whole, and increasing use is being made of some of the simpler statistical charts and calculations.

II. SOME NOTES ON THE THEORY OF PROBABILITY

1. The single sample or set of observations

In the theory of errors, a set of n equally reliable observations is considered as a sample of n drawn at random from an indefinitely large supply (parent population) of observations that theoretically *might* be made if time and opportunity would permit. In the state of statistical control or randomness, the observations behave as if they are numbers being drawn from a hat, after thorough mixing and blindfolding. This limiting state is a goal toward which the efforts of experimentation are always directed, but the requirement for its full attainment, as judged by Shewhart's "Criterion I" [9], is much more exacting than that in the experimenter's judgment the observations have all been taken under "essentially the same conditions."

If there were no constant errors, and if randomness were attained, the mean of the parent population of observations would be the true value of the quantity being measured. The effect of a constant error is to displace the mean of the parent population above or below the true value; the correction, if ever isolated and evaluated, can be added to or subtracted from the mean of the parent population to obtain the true value.

The object of making observations is to estimate the limits within which various percentages of the next hundred or thousand observations will lie; that is, statistically, to estimate the position (value) of the mean of the parent population. Because the number taken must necessarily remain finite, the exact value of the mean of the parent population can only be approached, even in controlled experiments, where randomness exists, and one becomes increasingly interested in the probabilities associated with certain propreties of the observations that are actually made. That is to say, if $\bar{x}$ is the mean of n observations and μ is the (unknown) mean of the parent population, one might be interested in knowing the proportion of means in sets of n observations each that will differ from μ by a stated amount, or the proportion in which an interval such as $\bar{x} \pm A$ will cover μ.

In the present discussion the observations will be considered randomly drawn from a parent population that is normal (Gaussian) or nearly so. There are four reasons for this choice: First, mathematically, the normal error curve is the easiest to deal with; second, it is usually an excellent approximation when control exists; third, several investigations on nonnormal populations have shown that even considerable departures from normality do not produce appreciable alterations in many important deductions based on the normal curve; and, fourth, it has been established that the distribution curve formed by the means of samples drawn from a nonnormal parent population is usually much more nearly normal than the population itself. While there exist several types of measurement that by nature do not have normal parent populations, deductions based on the normal law will rarely fail to be valid, provided control exists.

It is to be understood that the extreme tails or ends of the normal error curve do not represent probabilities for large errors. By the nature of the apparatus, extremely large errors may be absolutely impossible, yet the approximating normal curve attributes to these large errors a finite chance of occurrence. The normal curve is an approximation not expected to hold for large errors; it is the main portion of the curve that contributes most to the calculations: if the tails of the curve were cut off, the mathematical difficulties would be exceedingly complex, but with results, in moderate and large samples, practically not different from those obtained by the customary and simpler theory which includes the tails.

If μ denotes the mean of the parent population, then the true *error* of an observation x_i drawn therefrom will be

$$\epsilon_i = x_i - \mu. \tag{1}$$

Since μ is unknown, the error ϵ_i is also unknown. So, instead of dealing with the true but unknown errors ϵ_i, we shall find it advisable to work with the known *residuals* or *apparent errors* v_i, which are measured from the known mean $\bar{x}$ of the sample rather than from the unknown mean μ of the parent population. The definition of the residual corresponding to the observation x_i is mathematically

$$v_i = x_i - \bar{x}, \tag{2}$$

where $\bar{x}$ is the mean of the sample, defined mathematically as

$$\bar{x} = (1/n)(x_1 + x_2 + \cdot\cdot\cdot + x_n), \tag{3}$$

$x_1, x_2, \cdot\cdot\cdot, x_n$ constituting the sample of n observations.

The only difficulty in replacing μ by $\bar{x}$ and thus passing from the unknown errors (ϵ) to the known residuals (v) is that $\bar{x}$ itself fluctuates from one sample to another, and in any particular sample (set of observations) the discrepancy u between $\bar{x}$ and μ is in practice not known. This unknown error in $\bar{x}$ we shall denote by u, writing

$$u = \bar{x} - \mu. \tag{4}$$

Most of the deductions made from experimental data, by probability theory or any other method, are mainly concerned with the magnitude of u, the unknown error in the sample mean $\bar{x}$.

For laying odds concerning the error u in the mean $\bar{x}$, the most important piece of information provided by the sample is the standard deviation for single observations of the set, denoted by s and defined by

$$s^2 = (1/n)\Sigma(x_i - \bar{x})^2. \tag{5}$$

The standard deviation received its name from Karl Pearson. It is not standard in the sense of being fixed, since it fluctuates from one set of observations to another. It does, however, provide a standard measure for expressing the consistency of a set of observations, for comparing their consistency with that of another set, and for judging statistically from the results obtained at two laboratories whether constant errors are present in one or another of them.

In the usual form of probability theory, which applies when control has been attained, it is assumed that as the number of observations is increased indefinitely, the mean $\bar{x}$ approaches statistically the limit μ, and also that the standard deviation, s, approaches a limit σ, called the standard deviation of the parent population. In symbols,

$$\operatorname*{Lim}_{n\to\infty} \bar{x} = \mu \qquad \text{and} \qquad \operatorname*{Lim}_{n\to\infty} s = \sigma. \tag{6}$$

Under these conditions, the experiments are "under control." When the assumption of such limits does not lead to useful results, the probability theory in the usual form is not applicable.

The standard deviation, s, as defined in eq. 5, or any multiple thereof, possesses two important properties that make it the most desirable function to use as a measure of consistency. The first of these arises from the theorem known as Tchebycheff's inequality,[2] which has been stated in a variety of forms, one corollary being that of the n observations, $x_1, x_2, \cdots, x_n$, not more than $1/\lambda^2$ of them can be outside the interval $\bar{x} \pm \lambda s$, when $\lambda > 1$. The second is Gauss's discovery that when the observations have a normal distribution, the standard deviation, s, is more efficient for estimating σ than any other function. For example, the standard deviation is 14 percent more efficient than the average residual taken without regard to sign, and 9 percent more efficient than the mean cube of the residuals.[3] That

[2] See pp. 95–98 and elsewhere in Shewhart [3], and pp. 579–587 of Smith [4].

[3] See p. 201 of Whittaker and Robinson [5].

is to say, the standard deviation of 100 observations provides as statistically reliable an estimate of σ as the average residual, taken without regard to sign, from 114 observations; etc.

When an observer performs a number of sets of measurements of the same quantity with the same apparatus, he will find that the standard deviation fluctuates from one set of measurements to another, as has been stated. These fluctuations will occur even under the best controlled conditions. The larger the number n of observations in a given set, the smaller are the fluctuations in s. When n is large, considerable confidence may be placed in the precision of a set of experiments estimated from their standard deviation. The number of observations n enables one to judge the reliability of the estimates of the precision of the observations from their standard deviations. The number n tells how many figures are significant in recording s, a good rule being to remember that the standard deviation of s itself is about $\sigma/\sqrt{2(n-1)}$. For example, if $n=9$, $1/\sqrt{2(n-1)}=1/4$, and therefore one need record not more than two figures in s and, at that, the second figure is barely significant. More than two figures in s will hardly ever be required, though one extra figure will avoid errors of rounding off.

Various tests have been proposed by statisticians for determining the probability that a sample of n observations will reproduce the properties of the parent population within stated limits, that is to say, how well the mean $\bar{x}$ and the standard deviation, s, of a finite number of observations n will represent the mean μ and the standard deviation σ that would be obtained by continuing the measurements indefinitely. Also, calculations have been made for evaluating the odds on the occurrence of given differences between the means of two sets of observations.

The normal curve showing the distribution of the mean values of samples or sets of n observations has for its standard deviation $\sigma/\sqrt{n}$, which is smaller than σ because of the denominator $\sqrt{n}$. This quantity $\sigma/\sqrt{n}$ can be used to compute the probability that expresses the chance P_τ of the occurrence of an error u in $\bar{x}$ greater than some stated amount, say E. The graph in Fig. 1 shows P_τ as a function of τ, where

$$\tau = E/(\sigma/\sqrt{n}). \tag{7}$$

This quantity τ is the "standardized error," or the stated error E expressed in units of the standard deviation of the error u in $\bar{x}$. In the long run of repeated sampling under controlled conditions the stand-

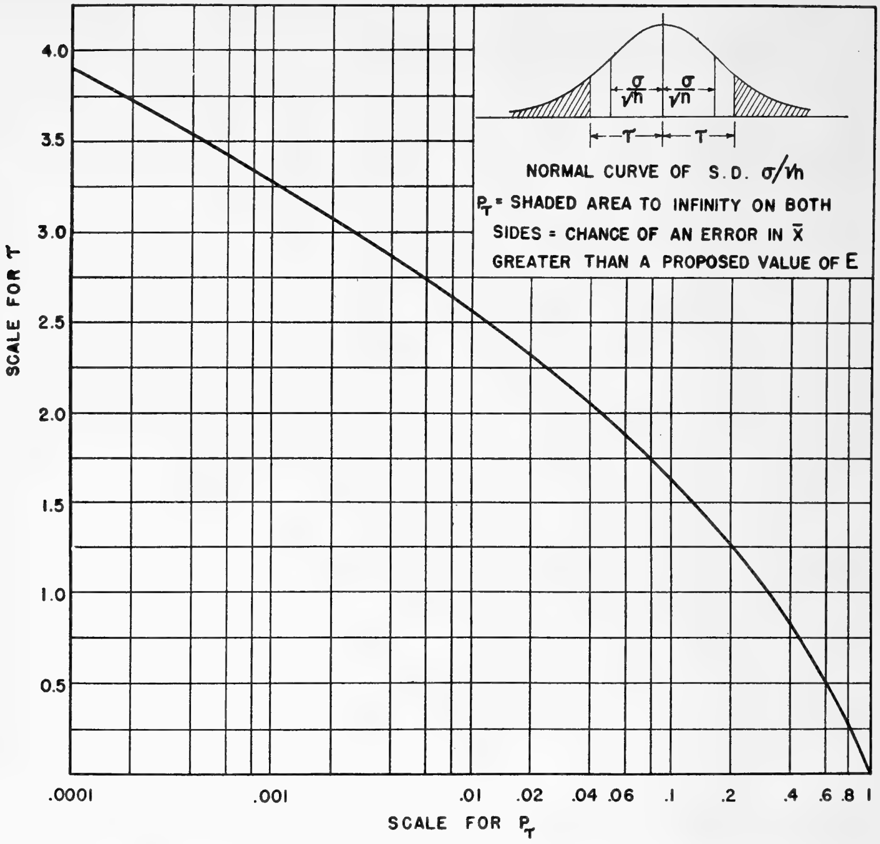

Fig. 1.—Areas under the normal curve. P_τ is the area in both tails beyond the abscissas $\pm\tau$. The whole area under the curve is unity, i. e. $P_\tau = 1$ when $\tau = 0$.

ard deviation of the error u is $\sigma/\sqrt{n}$, as has already been mentioned, and P_τ is the fractional number of times that the error u in $\bar{x}$ will in the long run exceed the stated error E. The calculation of τ and the corresponding P_τ is called the normal test for the significance of $\bar{x}$.

Reliable estimates of σ for the normal test can sometimes be made antecedently from a long series of previous observations, or from several short series,[4] and it is to be noted that in the absence of a reliable estimate of σ, one can not compute τ and hence can not look up P_τ in the tables. The best one can do in such circumstances is to use the Student "t" test [1, 6], which involves the fluctuating standard deviation, s, of the single sample, in place of the steady (but now supposedly unknown) σ. The "t" test is made by estimating σ from the one sample according to the formula

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[4] See Deming and Birge [1], eq. 67, p. 158.

$$s' = s\sqrt{n/(n-1)} = \sqrt{\frac{\Sigma(x_i - \bar{x})^2}{n-1}}, \tag{8}$$

and then measuring E in terms of $s'/\sqrt{n}$, calling the result t. Now if s' is an estimate of σ, then $s'/\sqrt{n}$ is an estimate of $\sigma/\sqrt{n}$, wherefore, if we write

$$t = E/(s'/\sqrt{n}) = E \div \sqrt{\frac{\Sigma(x_i - \bar{x})^2}{n(n-1)}}, \tag{9}$$

we may look upon t as an estimate of τ, the only distinction being that τ in eq. 7 is the stated error E measured in units of $\sigma/\sqrt{n}$, whereas t in eq. 9 is measured in units of an *estimate* of $\sigma/\sqrt{n}$. In words, t is the stated error E measured in units of the estimated standard deviation of the error u in $\bar{x}$. Otherwise written, we may say that

$$t = (E/s)\sqrt{k}, \tag{9a}$$

wherein $k = n - 1$, and s is computed according to eq. 5. In place of the probabilities P_τ in terms of τ in Fig. 1, we now have the probabilities P_t in terms of t and k in Nekrassoff's nomograph shown as Fig. 2. P_τ is to be used when σ is known; P_t when σ is not known.

It is to be kept in mind that P_τ, when we are able to calculate it, may be found different from P_t; in fact, the two will agree only when the observed s happens to be an "average" s. If s is unusually high or low, as it will be once in a while, then P_t will be correspondingly low or high compared with P_τ. It is to be remembered also that neither the normal test nor the "t" test is valid except in statistical control, and by the time this state is attained the experimenter usually knows his σ and has no need of the "t" test.[5] In statistical control, as n increases indefinitely, s' approaches σ, t approaches τ, and P_t approaches P_τ.

2. A pair of samples or sets of observations

The following information will be available from the recorded data of the two sets of observations:

	1st set	*2d set*
Mean	$\bar{x}_1$	$\bar{x}_2$
Standard deviation	s_1	s_2
Number of observations	n_1	n_2

In examining the concordance of two sets of measurements sup-

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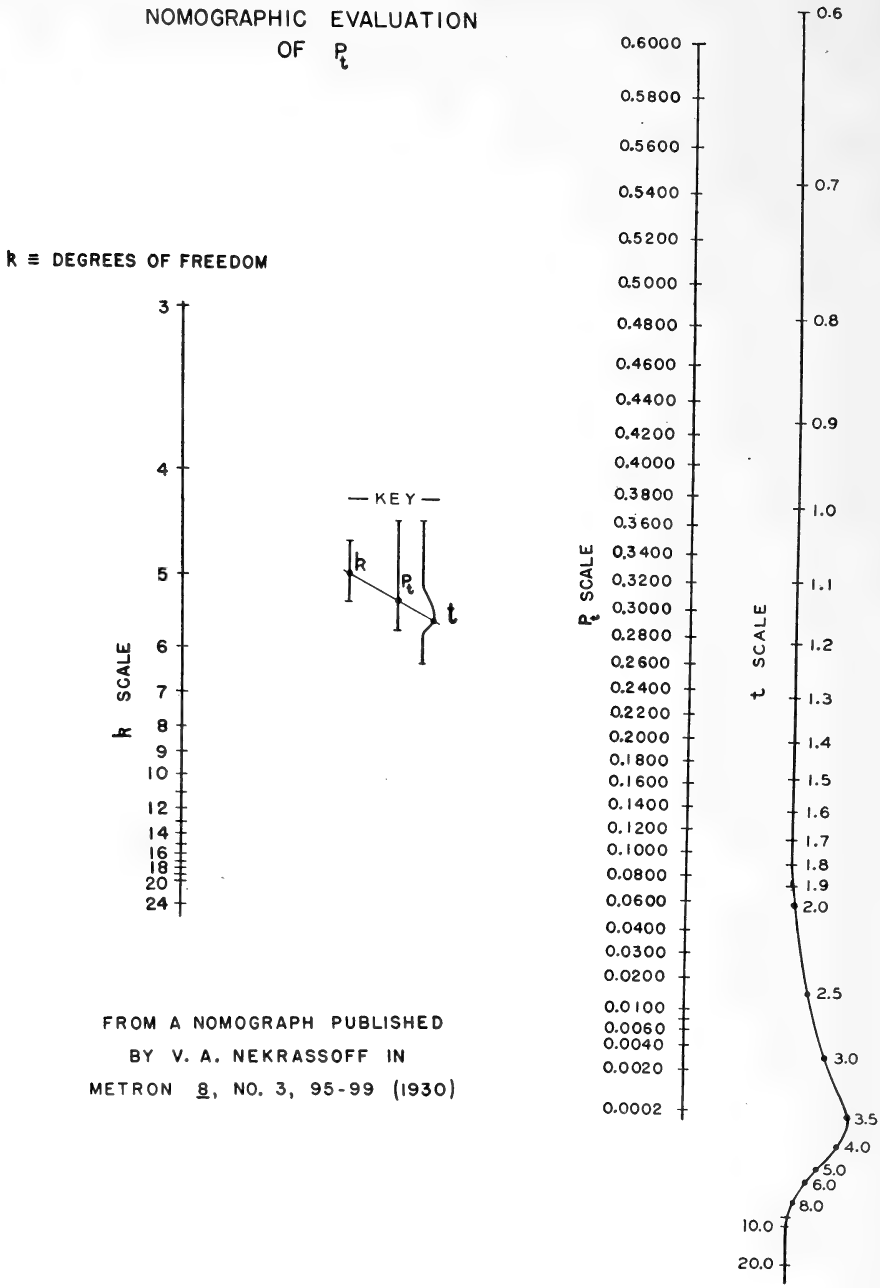
[5] For some critical remarks, see the 1937 and 1938 editions of Deming and Birge [1], especially the "additional notes" and pp. 131–139.



FROM A NOMOGRAPH PUBLISHED BY V. A. NEKRASSOFF IN METRON 8, NO. 3, 95-99 (1930)

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Fig. 2.—Nomographic evaluation of P_t.

posedly made on the same magnitude, the important fact to keep in mind is that if both sets are under control, then, in repeated sampling, the difference $\bar{x}_1-\bar{x}_2$ between the two means will be distributed normally about 0 with standard deviation $(\sigma_1^2/n_1+\sigma_2^2/n_2)^{1/2}$, σ_1 and σ_2 being the precisions of single observations in the two samples. To discover the probability of a difference as great as or greater than that actually observed, we need only calculate

$$\tau = \left| \bar{x}_1 - \bar{x}_2 \right| / (\sigma_1^2/n_1 + \sigma_2^2/n_2)^{1/2}, \tag{10}$$

and then look up P_τ in Fig. 1 or in any table of the normal integral.

In the case of the single sample we ran into the difficulty that σ is sometimes unknown, and we were forced to the "t" test. So it is with a pair of samples also; when σ_1 and σ_2 are both unknown, we can not compute τ in eq. 10 and hence can not look up P_τ. But if, as frequently happens, it can be asserted that σ_1 and σ_2 have a common value, say σ, then we may apply the "t" test by calculating

$$t = \left| \bar{x}_1 - \bar{x}_2 \right| / s' \left(\frac{1}{n_1} + \frac{1}{n_2} \right)^{1/2}, \tag{11}$$

with

$$s'^2 = \frac{n_1 s_1^2 + n_2 s_2^2}{n_1 + n_2 - 2}, \tag{12}$$

and then looking up P_t on Nekrassoff's nomograph (Fig. 2) with $k=n_1+n_2-2$. It is to be noted that s' is an estimate of σ obtained by pooling both samples, and that t as defined in eq. 11 is the difference $|\bar{x}_1-\bar{x}_2|$ divided by $s'(1/n_1+1/n_2)^{1/2}$, which is the estimated standard deviation of the sampling fluctuation of $\bar{x}_1-\bar{x}_2$. We may therefore look upon t in eq. 11 as an estimate of the τ in eq. 10, the relation between them being similar to that between the t and τ of eqs. 9 and 7.

In the state of statistical control, P_t represents the relative frequency of occurrence, in the long run, of values of t as large as or larger than that calculated in eq. 11, the presumption being that both sets of observations were made on the same thing, i. e., that both sets were afflicted with the same constant errors. A large value of t, giving a low value of P_t, is an indication that the two means $\bar{x}_1$ and $\bar{x}_2$ are unduly discordant compared with their internal consistencies as measured by s_1 and s_2. Since unequal constant errors in the two experiments would separate $\bar{x}_1$ and $\bar{x}_2$, on the average, leaving s_1 and s_2 and s' unaffected, we may regard a low value of P_t as statistical "evidence" of unequal constant errors. A low value of P_t, e. g., 0.01, is of course no proof of the existence of constant errors, but rather an indication that an investigation into the possibility should be made. On the other hand, a high value of P_t is no assurance that constant errors are absent or operating equally. One can only assert that an unequal distribution of constant errors causes low values of P_t to occur more frequently than would happen by chance under ideal conditions.

When, because of unavoidable circumstances, the numerical data of a given investigation can not be published in complete detail, the procedure of estimating and reporting the measure of the precision should preserve as much as possible of the information contained in the full series of observations. In those cases where complete publication is not possible, condensation of the numerical data becomes necessary, and the investigator should report at least the three following pieces of information

(i) The number of observations, n.

(ii) The mean $\bar{x}$ of the observed values, calculated to as many figures as are judged significant in consideration of the standard deviation.

(iii) The standard deviation, s, given to as many figures as are judged significant in consideration of the number of observations.

The number of significant figures to which the mean value $\bar{x}$ is reported should be dictated by the internal consistency of the observations, that is, by the magnitude of the standard deviation, and not by what one may consider to be the accuracy of the experiments. If one or more decimals are dropped from a mean, it may be impossible to correct it to a more accurate value later on when one or more constant errors may be traced and evaluated. Furthermore, a comparison of the discrepancy between two means with the internal consistencies of the two sets of observations is hardly possible unless each mean is carried out to as many significant figures as are warranted by the standard deviation.

3. Functional concordance

Hitherto the n measurements were all supposed to have been made on a single magnitude. Quite commonly, however, one has to deal with a more complicated case of curve fitting; some measurements may be here, and others there, as happens for example when a vapor pressure is observed as a function of the temperature. As the temperature changes, so does the vapor pressure, and one may wish to observe the vapor pressure at several different temperatures, and afterward fit a curve to the observed points. Sometimes only one measurement is taken on y for a given x, or on x for a given y, but it is highly desirable that repeated observations be made whenever possible, in order to see how well the curve fits (see, for example, pp. 20–25 of Deming's *Least Squares* [12]). Sometimes only y is subject to error; but more generally x and y may both be in error, in which case the problem of adjustment is still easily taken care of (cf. Deming [12], pp. 82 and 83 ff). In any event, when the curve has been fitted, an estimate of the precisions of the observations on y and x can be made.

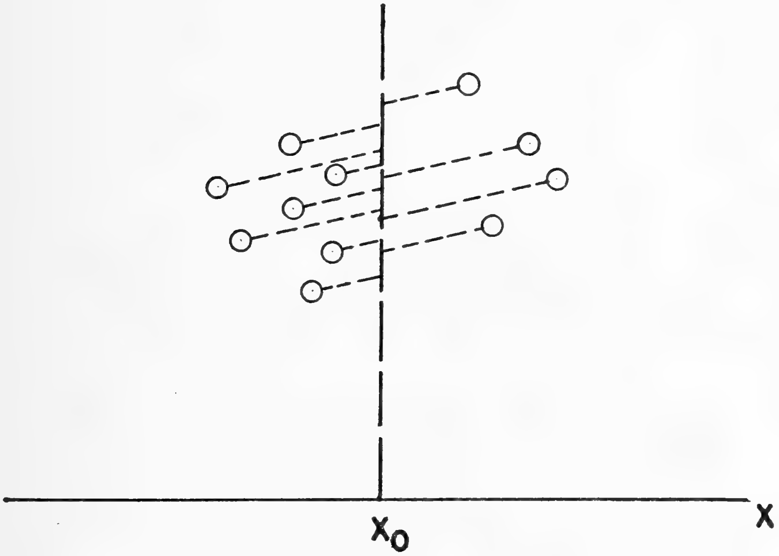

Fig. 3.—Here y is observed for several values of x, none of which is far from x_0. If one knows the slope dy/dx of the functional relation between x and y at x_0, or knows the shape of the relation in that vicinity, he can easily project the observations to find the concordance at x_0, i. e., to find what might have been obtained if x had been held at x_0.

Occasionally, y is observed for several values of x within a range close of x_0. One can then, in effect, move the points graphically to the abscissa x_0 as shown in Fig. 3. The standard deviation of y at x_0 can easily be computed by taking the root mean square deviation of y from its mean value at x_0 according to eq. 5.

III. PROPAGATION AND COMBINATION OF ERRORS

If the quantity F is a function of x, y, and z, and these are in error by the amounts Δx, Δy, and Δz, respectively, then F will be in error by an amount ΔF whose value is given approximately by the linear terms of a Taylor's series:

$$\Delta F = F_x\Delta x + F_y\Delta y + F_z\Delta z + \cdots. \tag{13}$$

Here the higher powers and products of Δx, Δy, and Δz have been neglected, since it is assumed that the errors are small. (F_x, F_y, and F_z stand for dF/dx, dF/dy, and dF/dz, respectively, and each derivative is to be evaluated at or near the correct values of x, y, and z.) Eq. 13 is the equation of propagation of error.

In practice, one does not know the individual errors in x, y, and z, but may have some knowledge regarding their standard deviations from long series of measurements. These standard deviations, denoted by σ_x, σ_y, and σ_z, are respectively the square roots of the averages of $(\Delta x)^2$, $(\Delta y)^2$, and $(\Delta z)^2$ in very long series of observations.

Upon squaring both sides of eq. 13 we have

$$\begin{aligned}(\Delta F)^2 = (F_x\Delta x)^2 + (F_y\Delta y)^2 + (F_z\Delta z)^2 + 2F_xF_y\Delta x\Delta y \\ + 2F_xF_z\Delta x\Delta z + 2F_yF_z\Delta y\Delta z.\end{aligned} \tag{14}$$

Assuming that F_x, F_y, and F_z remain substantially constant while Δx, Δy, and Δz vary over their allowable ranges, and that the averages of the cross products $\Delta x\Delta y$, $\Delta x\Delta z$, and $\Delta y\Delta z$ are zero, as will be true if Δx, Δy, and Δz are uncorrelated, one may average each term of eq. 14 and obtain

$$\sigma_F{}^2 = F_x{}^2\sigma_x{}^2 + F_y{}^2\sigma_y{}^2 + F_z{}^2\sigma_z{}^2. \tag{15}$$

This is the equation of the propagation of the standard deviation, when the errors are independent. Two examples of its application to various simple functions follow.

(i) If

$$F = ax + by + cz, \tag{16}$$

where the errors in x, y, and z are independent of one another, then the standard deviation of F, resulting from the errors in x, y, and z, is given by the relation

$$\sigma_F = \left\{a\sigma_x)^2 + (b\sigma_y)^2 + (c\sigma_z)^2\right\}^{1/2}. \tag{17}$$

Here σ_x, σ_y, and σ_z are the standard deviations of the errors in x, y, and z. It is to be noted that this formula remains unaltered if a, b, or c changes sign.

(ii) If

$$F = x^\alpha y^\beta z^\gamma, \tag{18}$$

where the errors in x, y, and z are independent of one another, then the resulting standard deviation of F is

$$\sigma_F = F\left\{(\alpha\sigma_x/x)^2 + (\beta\sigma_y/y)^2 + (\gamma\sigma_z/z)^2\right\}^{1/2}. \tag{19}$$

This formula remains unaltered if α, β, or γ changes sign.

Separately obtained mean values, if within reasonable accord with one another, may be combined by weighting them inversely as the squares of their standard deviations. (Just whether two sets of observations are in accord with one another is a matter that can not be decided objectively, but the normal test or the "*t*" test will at times be of assistance.) If, for example, three sets of measurements of a certain quantity yield the three means $\bar{x}_1$, $\bar{x}_2$, and $\bar{x}_3$, the resulting weighted mean will be

$$\bar{x} = \frac{n_1\bar{x}_1/\sigma_1^2 + n_2\bar{x}_2/\sigma_2^2 + n_3\bar{x}_3/\sigma_3^2}{n_1/\sigma_1^2 + n_2/\sigma_2^2 + n_3/\sigma_3^2}, \tag{20}$$

wherein n_1, n_2, and n_3 are the numbers of measurements in the three sets, and σ_1, σ_2, and σ_3 express the standard deviations of single observations.

The standard deviation to be assigned to the resulting weighted mean $\bar{x}$ will be

$$\bar{\sigma}_{\bar{x}} = 1/(n_1/\sigma_1^2 + n_2/\sigma_2^2 + n_3/\sigma_3^2)^{1/2}. \tag{21}$$

The bar over the σ is a reminder that the character refers to a mean.

If in the same symbolism $\bar{\sigma}_1$, $\bar{\sigma}_2$, and $\bar{\sigma}_3$ refer to the standard deviations of the three separate means $\bar{x}_1$, $\bar{x}_2$, and $\bar{x}_3$, eqs. 20 and 21 take the forms

$$\bar{x} = \frac{\bar{x}_1/\bar{\sigma}_1^2 + \bar{x}_2/\bar{\sigma}_2^2 + \bar{x}_3/\bar{\sigma}_3^2}{1/\bar{\sigma}_1^2 + 1/\bar{\sigma}_2^2 + 1/\bar{\sigma}_3^2}, \tag{22}$$

$$\bar{\sigma}_{\bar{x}} = 1/(1/\bar{\sigma}_1^2 + 1/\bar{\sigma}_2^2 + 1/\bar{\sigma}_3^2)^{1/2}. \tag{23}$$

These formulas are easily extended to any number of sets of observations.

IV. APPLICATION TO MEASUREMENTS IN GENERAL

The calculations outlined on the preceding pages may be applied to any experiment that is in statistical control; i. e., when the data are known to be random.[6] Possible examples that can be developed in general physical and chemical measurements are the determinations of heats of chemical reactions, heat capacities, heats of fusion and vaporization, freezing and boiling points, volumes, molecular weights, densities, refractive indices, solubilities, and various chemical analyses.

Physical and chemical measurements may be divided roughly into

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[6] See, in particular, chapter II of Shewhart [9].

two classes, of which the second is further subdivided into two parts:[7]

A. Absolute or primary measurements.
B. Comparative or secondary measurements.
  a. By successive comparison.
  b. By simultaneous comparison.

In physicochemical measurements, the investigator must carefully distinguish between the precision and the accuracy of his results, and, furthermore, he must establish beyond reasonable doubt that the purity of the chemical substances upon which the measurements are being made is sufficient for the purposes of the investigation. Methods for establishing the purity of chemical substances have been discussed in detail by a number of authors (for example, see Washburn [8]).

There are relatively few investigations that in themselves completely determine the final value of a desired property. Usually the final value is a function of a number of quantities, only one of which will be evaluated in the investigation, the others being "accepted" from other sources. For example, the final value Q may be a function of the quantities A, B, and C, of which C is the only one that is evaluated in the investigation: thus, it might be that

$$Q = ABC. \tag{24}$$

The precision of the measurements on C is a measure of the precision of C but not of Q. The precision of $C(=Q/AB)$ may be considered the "immediate" precision of the measurements, and this is to be contrasted with the "overall" precision of Q, which must include the precisions of A and B as well as of C. The standard deviation to be assigned to A and B should be estimated, in a manner similar to that used in estimating the standard deviation of C, from measurements made in the laboratories where A and B were determined. When no systematic errors exist in A or B or C, then the "overall" standard deviation, estimated by the propagation of the standard deviations of the various component parts, gives an idea of the accuracy of the experiment. It is only through the concordance of different methods of measurement that a measurable characteristic is ever said to have an existence that is operationally verifiable; but no matter how close this concordance appears to be, there is always the possibility that future experimental or theoretical work may reveal the presence of constant errors, whereupon our ideas concerning the accuracy of a

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[7] For further definition and discussion of absolute and relative measurements, see Swietoslawski [7].

measured quantity will need to be revised (cf. Shewhart [9], chapter IV).

Absolute or primary measurements are those in which the resulting magnitude is measured in terms of fundamental or absolute standards. Examples of this class include the determination of the density of water in terms of the fundamental units of mass and volume; the heat of formation of water in terms of the fundamental unit of energy; and the absolute viscosity of water in terms of fundamental units. For such measurements the finally determined value of Q will be the resultant of sets of measurements on one or more magnitudes. The standard deviation of the magnitude resulting from each of the component sets of observations may be estimated according to the procedure discussed in Section II, these separate standard deviations then being combined by the procedure given in Section III for the propagation of errors. Strictly, the formulas developed there are valid only for the true values of the standard deviations involved, but they will be sufficiently close for the purpose when used with estimated standard deviations.

Comparative or secondary measurements are those in which the resulting magnitude is determined by comparison with a selected standard or reference substance, in terms of a "best" value more or less arbitrarily assigned or accepted for the standard. For such measurements, it is to be emphasized that the evaluation of the "overall" standard deviation of the resulting value entails a consideration not only of the errors in the immediate experiment, but also of the uncertainty in the value selected for the standard substance in terms of the fundamental units. This latter uncertainty must be inferred from absolute or primary measurements made in a laboratory adequately equipped to determine the value for the standard substance in terms of the fundamental units.

Secondary measurements involving successive comparison with the standard or reference substance include, for example, the determination of the viscosity of a liquid with a viscosimeter standardized with water (using an "accepted" value for the latter) and the determination of the heat of combustion of an organic substance with a bomb calorimetric apparatus standardized with benzoic acid. In such measurements, the final value Q is the resultant of two sets of measurements with the same apparatus under as nearly the same conditions as possible. In one set the reference substance is measured, and in the other the experimental substance. This type of measurement determines the ratio of the property for the one to that for the other, as for example, Q_w/Q_r. If the estimated standard deviations (Section II) are respectively σ_w and σ_r, then for Q_w/Q_r, which measures Q_w in terms of the units and value accepted for the standard, the resulting standard deviation is that obtained by combining σ_w and σ_r in a manner indicated in Section III. It should be noted that this result takes no account of the uncertainty in the value selected for the standard substance.

Secondary measurements involving simultaneous comparisons of the given substance with the standard or reference, include, for example, the determination of relative heat capacities with "twin" calorimeters, of relative P-V-T data with "twin" bombs, and of relative densities with "twin" pycnometers. In such measurements, the final value Q is usually the result of measurements with a "twin" apparatus containing both the given substance and the reference or standard. This type of measurement substantially determines the difference between the value of the property for the experimental substance and that for the reference substance, as for example, $Q_w - Q_r$. In practice the reference substance is selected to make the observed difference $Q_w - Q_r$ small in comparison with Q_r. The resulting standard deviation for the value of Q_w, expressed in terms of the units and value adopted for the reference substance, will be simply the standard deviation for the value $Q_w - Q_r$, evaluated from the data according to the procedure given in Sections II and III. This standard deviation likewise takes no account of the uncertainty in the value selected for the reference substance.

V. SPECIFIC RECOMMENDATIONS FOR THERMOCHEMISTRY

1. General remarks

In thermochemical investigations, systematic errors may arise from a number of sources, including the evaluation of the energy equivalent of the calorimeter, the determination of the amount of reaction, etc.[8] Such systematic errors, which affect the accuracy but usually not the precision of the results, may preclude agreement among different laboratories as to the results of measuring what is supposedly the same thing, even though the consistency of the measurements in each of the laboratories by itself is entirely satisfactory.

The standard deviations associated with the "accepted" constants and other constant factors entering into the reduction of the data should be incorporated, so far as they are significant, into the final "overall" standard deviation assigned to the quantity being evalu-

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[8] For a detailed discussion of such factors, see reference [10].

ated. In the report of an investigation, such constants and their assigned standard deviations should be identified and the reasons for their selection given.

The standard deviation that is to be associated with the mean $\bar{x}$ of a set of n observations in a state of statistical control is $1/\sqrt{n}$ times the standard deviation (for single observations) of the parent population from which the observations are drawn (see Section II). An estimate $\bar{s}'$ of the standard deviation of $\bar{x}$ can therefore be obtained by multiplying s' in eq. 8 by $1/\sqrt{n}$, whence

$$\bar{s}' = s'/\sqrt{n} = \sqrt{\Sigma v_i^2/n(n-1)}, \qquad (25)$$

where Σv_i^2 is the sum of the squares of the deviations, each deviation being measured from $\bar{x}$, that is, $v_i = x_i - \bar{x}$, as in eq. 2. (It will be recalled that s' is the estimated standard deviation for single observations of a given set, and that $\bar{s}'$ is the estimated standard deviation of the mean $\bar{x}$.)

It is again emphasized that the procedure described here for treating the observations of experimental thermochemistry statistically is applicable only if the observations are in a state of statistical control (see Section II).

2. Procedure for combining standard deviations

Following the general classification already given in Section IV, calorimetric investigations of the heats of chemical reactions may be divided into those involving (A) absolute or primary measurements and (B) comparative or secondary measurements.

A. Absolute or primary measurements

In thermochemical investigations involving absolute or primary measurements, the heat evolved by a measured amount of chemical reaction is compared with the heat evolved by a measured amount of electrical energy, using the calorimeter system as the absorber and comparator of the two kinds of energies. In the ideal case, both a fixed calorimeter system and a fixed temperature rise would be used, so that a direct equality would be obtained between a measured amount of electrical energy and a measured amount of chemical reaction [10].

In actual practice it is easy to use a fixed calorimeter system but impracticable to try to obtain exactly the same temperature rise in all experiments. Instead, with the fixed calorimeter system, the temperature rise is made substantially the same in all experiments, and the small differences from one experiment to another are measured in order to effect the correction to a common temperature rise. In most cases the amount of electrical or chemical energy added to the calorimeter can be so regulated that the differences in the temperature changes in the various experiments will differ from zero by at most several percent of the total change. Since the small differences can be measured as precisely as necessary, the advantage of the substitutional nature of the method is retained, and the experimenter gains some needed flexibility in operation.

For the given calorimeter system, it is convenient to determine a quantity called its energy equivalent.[9] This quantity A is the amount of electrical energy E added to the fixed calorimeter system divided by the temperature rise Δt_E, the amount of energy added being regulated so that Δt_E differs little from the selected "standard" temperature rise. The relation used in computing the energy equivalent of the calorimeter is

$$A/f = E/\Delta t_E, \tag{26}$$

where E is the observed electrical energy, Δt_E is the observed temperature rise, A is the energy equivalent of the calorimeter, and f is a constant whose value is the resultant of the various calibration factors associated with the instruments used in measuring the electrical energy, such as the standard resistances, standard cell, resistance coils of the potentiometer, timing apparatus, etc. The product fE gives the electrical energy in terms of fundamental units. In the experiments with electrical energy, the quantities actually observed are E and Δt_E, and for each experiment there is determined a value of the ratio $E/\Delta t_E$. From a series of n such determinations of $E/\Delta t_E$, there is obtained an average value of $E/\Delta t_E$, this average being the experimental determination of A/f according to eq. 26. By applying eq. 25 to the measurements of $E/\Delta t_E$ one may calculate

$$\bar{s}'_{A/f} = \sqrt{\Sigma v_i^2/n(n-1)} \tag{27}$$

as an estimate of the standard deviation to be assigned to the determination of A/f.

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[9] This quantity is substantially the same as that which has been called by many writers the heat capacity of the calorimeter, but the latter designation is not recommended because it implies that the investigator has a knowledge of the actual physical boundaries of the material system to which the heat capacity is ascribed, and that the heat capacity of the calorimeter may be evaluated by a summation of the heat capacities of its component parts. As has already been pointed out [10], this latter procedure is not admissible in modern thermochemical investigations.

In a series of calorimetric reaction experiments, there is measured the amount of chemical reaction that produces, in the calorimeter, a temperature rise substantially equal to the selected "standard" temperature rise. The relation used in reducing the data of these experiments is

$$Bg = \Delta t_R / W_R, \tag{28}$$

where Δt_R is the observed temperature rise, W_R is the observed mass of the substance (either reactant or product) that is used to determine the amount of reaction, B is the temperature rise per unit mass of the selected substance that determines the amount of reaction, and g is a factor whose value is the resultant of the various factors required to convert the observed mass of the selected substance to the number of moles of the desired pure reaction, which conversion involves the molecular weight of the selected substance, a correction for any impurity in the reaction, etc. In the experiments with chemical energy, the quantities actually observed are Δt_R and W_R, and for each experiment there is determined a value of the ratio $\Delta t_R / W_R$. From a series of n such determinations of $\Delta t_R / W_R$, there is obtained an average value of $\Delta t_R / W_R$, this average being the experimental determination of Bg according to eq. 28. By applying eq. 25 to the measurements of $\Delta t_R / W_R$ one calculates

$$\bar{s}'_{Bg} = \sqrt{\Sigma v_i^2 / n(n-1)} \tag{29}$$

as an estimate of the standard deviation to be assigned to the determination of Bg.

The experimental value of the heat Q of one mole of the reaction being studied is obtained from the relation

$$Q = AB, \tag{30}$$

which can be written

$$Q = (E/\Delta t_E)(\Delta t_R / W_R) f/g. \tag{31}$$

The ratios $E/\Delta t_E$ and $\Delta t_R / W_R$ are evaluated in the electrical energy and the chemical reaction experiments, respectively, and the ratio f/g includes all the constant factors involved in the reduction of the data. In the experiments, Δt_E and Δt_R are made as nearly alike as possible, and since these temperature rises occur in eq. 31 only as the ratio $\Delta t_R / \Delta t_E$, the thermometer need not be calibrated in an absolute sense. In fact, the substitutional nature of the experiments can be further emphasized by reporting the values of Δt_E and Δt_R

in the units in which they are actually measured (microvolts if the thermometric device is a thermoelement and ohms if it is a resistance thermometer) without conversion to degrees on the temperature scale.

By an appropriate analysis of the information supplied by the standardizing and other laboratories, the investigator may be able to estimate the magnitude of the standard deviations associated with the constant factors f and g used in reducing the data. If these estimates are denoted by $\bar{s}'_f$ and $\bar{s}'_g$, then, by comparing eqs. 18 and 31 and applying eq. 19, the final "overall" standard deviation to be assigned to the experimental value of Q is found to be

$$\bar{s}'_Q = Q\sqrt{[\bar{s}'_{A/f}/(A/f)]^2 + [\bar{s}'_{Bg}/Bg]^2 + [\bar{s}'_f/f]^2 + [\bar{s}'_g/g]^2}. \tag{32}$$

The value of $\bar{s}'_Q$ given by eq. 32 is seen to be derived from a combination of four terms, the first from the experiments with electrical energy, the second from the experiments with chemical energy, and the third and fourth from the constant factors used in reducing the data. In the actual practice of thermochemical investigations, the uncertainties in the calibration factors to be applied to the nominal values of the standard resistances, standard cells, etc., are nearly always negligible, or can be made so by appropriate calibration at the national standardizing laboratory. Likewise, the correction for an impurity in the reaction, if any is present, can usually be made with negligible uncertainty by application of the appropriate analytical technic in the chemical analysis of the reaction [10]. It appears, therefore, that by adequate calibration and chemical techniques, the uncertainties in the factors f and g in eq. 31 can usually be made negligible in comparison with those of A/f and Bg. Under such circumstances the last two terms under the radical in eq. 32 may be neglected, and the final "overall" standard deviation to be assigned to the experimental value of Q becomes simply

$$\bar{s}'_Q = Q\sqrt{[\bar{s}'_{A/f}/(A/f)]^2 + [\bar{s}'_{Bg}/Bg]^2}. \tag{33}$$

B. Comparative or secondary measurements

In thermochemical investigations comparative or secondary measurements have so far been made only by successive comparison. In such experiments the heat evolved by a measured amount of the given chemical reaction is compared with the heat evolved by a measured amount of a selected "standard" or reference reaction, using a fixed calorimeter system with a substantially constant temperature rise. The heat evolved per unit amount of the selected reference reaction, which is chemically similar to the one being investigated, has been determined, in terms of fundamental units for the reaction occurring under certain standard conditions, in an appropriate standardizing laboratory. These comparative or secondary thermochemical measurements are the same as the absolute or primary ones except that the energy equivalent of the calorimeter is determined not with electrical energy but with the heat evolved by a measured amount of the standard or reference reaction taken under "standard" conditions.

The relation used in computing the energy equivalent of the calorimeter from the data of the experiments with the reference reaction

$$C/D = W_s/\Delta t_s, \tag{34}$$

is where W_s is the observed mass of that reactant or product of the standardizing reaction which is used to determine the amount of reaction, Δt_s is the observed temperature rise, C is the energy equivalent of the calorimeter in terms of the value and units assigned to the standardizing reaction, and D is the value assigned to the standardizing reaction for the heat evolved per unit mass of the reactant or product that determines the amount of reaction when the reaction occurs under the conditions maintained in the experiments in the standardizing laboratory. In the experiments with the reference reaction, the quantities actually observed are W_s and Δt_s, and for each experiment there is determined a value of the ratio $W_s/\Delta t_s$. From a series of n such determinations of $W_s/\Delta t_s$, there is obtained an average value of $W_s/\Delta t_s$, this average being the experimental determination of C/D according to eq. 34. By applying eq. 25 to the measurements of $W_s/\Delta t_s$, one may calculate

$$\bar{s}'_{C/D} = \sqrt{\Sigma v_i^2/n(n-1)} \tag{35}$$

as an estimate of the standard deviation to be assigned to the determination of C/D.

In a series of calorimetric reaction experiments, the reaction whose heat is to be determined is carried out under conditions substantially identical to those maintained in the experiments with the standardizing reaction. The relation used in reducing the data of these experiments is

$$Bg = \Delta t_R/W_R, \tag{36}$$

where Δt_R is the observed temperature rise, W_R is the observed mass of the reactant or product of the given reaction that is used to determine the amount of reaction, B is the temperature rise per unit mass of the selected substance that determines the amount of reaction, and g has the same significance as in eq. 28. In these experiments, the quantities actually observed are Δt_R and W_R, and for each experiment there is determined a value of the ratio $\Delta t_R/W_R$. From a series of n such determinations of $\Delta t_R/W_R$, there is obtained an average value of $\Delta t_R/W_R$, this average being the experimental determination of Bg according to eq. 36. By applying eq. 25 to the measurements of $\Delta t_R/W_R$ one may calculate

$$\bar{s}'_{Bg} = \sqrt{\Sigma v_i^2/n(n-1)} \tag{37}$$

as an estimate of the standard deviation to be assigned to the determination of Bg.

The experimental value of the heat Q of one mole of the reaction under investigation is obtained from the relation

$$Q = CB, \tag{38}$$

which can be written

$$Q = (W_s/\Delta t_s)(\Delta t_R/W_R)D/g. \tag{39}$$

The ratios $W_s/\Delta t_s$ and $\Delta t_R/W_R$ are measured in the two series of calorimetric reaction experiments, the first with the standardizing reaction and the second with the reaction whose heat is to be determined. The ratio D/g contains all the constant factors involved in the reduction of the data, including the value assigned for the heat of a unit amount of the standardizing reaction. As in the absolute or primary measurements, the temperature changes are made substantially the same in all experiments. The statement concerning the calibration of the thermometer following eq. 31 is also applicable here.

The value assigned to D, the heat of a unit amount of the standardizing reaction, has been previously determined in a standardizing laboratory and carries with it a standard deviation $\bar{s}'_D$ estimated according to the procedure outlined under absolute or primary measurements. Then the final "overall" standard deviation to be assigned to the experimental value of Q that is obtained from these comparative or secondary measurements is

$$\bar{s}'_Q = Q\sqrt{[\bar{s}'_{C/D}/(C/D)]^2 + [\bar{s}'_{Bg}/Bg]^2 + [\bar{s}'_D/D]^2 + [\bar{s}'_g/g]^2}, \tag{40}$$

where g and $\bar{s}'_g$ have the same significance as in eqs. 28 and 32.

If, as in the previous case, the uncertainty in the factor g is negligible in comparison with the others, then this equation may be simplified to

$$\bar{s}'_Q = Q\sqrt{[\bar{s}'_{C/D}/(C/D)]^2 + [\bar{s}'_{Bg}/Bg]^2 + [\bar{s}'_D/D]^2}, \tag{41}$$

where the first two terms under the radical arise from the two kinds of experiments performed by the investigator, and the third arises from the experiments made in the standardizing laboratory.

3. Discussion of the procedure

In connection with the foregoing procedure for evaluating the final "overall" standard deviations to be assigned to thermochemical values obtained either from absolute (primary) or comparative (secondary) measurements, the following points are to be noted:

(a) If more than one set of measurements of a given kind is made, the means and their respective standard deviations may be combined according to the procedure given in Section III, eqs. 15 ff;

(b) The number of experiments in any one set should be made sufficiently large to insure that the estimated standard deviations obtained for the magnitudes A/f, Bg, or C/D (see above) reasonably represent the behavior of the apparatus[10];

(c) Acceptable experiments include all except those in which a mistake or gross error has obviously been made, or in which an extraordinarily large deviation can be accounted for by purely physical means.

It is important to note also that the following assumptions have been made in estimating the standard deviations according to the procedure outlined here:

(a) The experiments are performed under conditions corresponding to a state of statistical control;

(b) The customary theory of probability, when applied to data in statistical control, gives in the long run the relative frequency with which intervals $\bar{x} \pm \lambda s$ (based on the observed mean value $\bar{x}$ and the consistency of the data, past or present) actually overlap the mean of a large number of observations;

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[10] In the investigations carried on in the thermochemical laboratory at the National Bureau of Standards (see reference [11] for a summary of most of them), the practical optimum number of experiments per set appears to be in the neighborhood of 8 to 12, depending upon the particular substance being studied, its availability in adequate quantities of the sufficiently pure material, etc. It is, of course, presupposed that the apparatus has been brought into a state of control by previous experimentation so that the observations recorded on the substance under investigation can be considered truly random.

(c) The limiting mean μ is called the value of the quantity whose measurement is the purpose of the experiments.

4. The uncertainty interval

To each experimental value determined in the thermochemical laboratory of the National Bureau of Standards there is assigned a number representing the uncertainty interval, within which future determinations of the given experimental quantity may with reasonable certainty be expected to lie.[11] The value adopted for this uncertainty interval is twice the final "overall" standard deviation, i.e.,

$$\textit{Uncertainty interval} = 2\bar{s}'_Q, \qquad (42)$$

where $\bar{s}'_Q$ is given by eq. 32 for the absolute or primary measurements, and by eq. 40 for the comparative or secondary measurements.

When two investigations yield, for a given thermochemical constant, values which differ by more than the sum of the two assigned uncertainty intervals, it is probable, but not at all certain, that a systematic error or combination of errors exists in one or both of the investigations. Conversely, when the two values are in accord within their assigned uncertainty intervals, it is probable, but not at all certain, that systematic errors are absent. When two such values differ by more than the sum of the assigned uncertainty intervals, it is desirable to reexamine the data of the experiments and ascertain whether all the necessary constant factors (see Section V-2) have been included and properly evaluated, and whether the standard deviations assigned to these constant factors have been properly estimated. Need of revision may be discovered either in the numerical values of the constant factors, or in the standard deviations assigned to them, or in both.

This assignment of uncertainty intervals to thermochemical values has, as a matter of record, been found to be of considerable practical usefulness in a number of thermochemical laboratories, and with appropriate limitations, their use is recommended to others engaged in similar work of determining thermochemical quantities.

The authors wish to acknowledge the benefit of discussion with L. W. Tilton.

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PALEONTOLOGY.—*A paleoniscid brain case.*[1] THEODORE H. EATON, JR., Union College, Schenectady, N. Y. (Communicated by C. LEWIS GAZIN.)

Present sources of information on the paleoniscid neurocranium are principally three: Stensiö (1921, *Birgeria mougeoti* from the Spitzbergen Triassic), Watson (1925, "*Paleoniscid A*" and "*Paleoniscid B*" from the Kansas Carboniferous), and Case (1937, a paleoniscid similar to Watson's "*A*," from the same horizon, Upper Pennsylvanian, Kansas City, Mo.). A specimen of the latter type, very kindly lent to me by Dr. Case, is the material for the present study. It is no. 18565, Museum of Paleontology, University of Michigan.

Important characteristics of the paleoniscid neurocranium, as shown in the papers cited, are these:

1. The brain case is tropibasic, an actinopterygian feature; that is, the large eyes have encroached on the interorbital wall until it disappeared, and the brain retreated accordingly to a position behind the eyes and between the auditory capsules.

2. Also associated with tropibasy is a myodome, a recess for the cranial attachment of the rectus eye muscles; this has eaten still farther into the brain case, beneath the anterior part of the auditory region on each side.

3. The endocranial ossifications are few but extensive, particularly a single anterior "sphenoid," paired "autosphenotics" forming the postorbital processes, and "prootico-occipitals" enclosing the auditory capsules (Stensiö, 1921). Watson (1925) found a narrow zone of chondrification separating the prootic from the occipital parts. This was confirmed by Case and is readily visible in the present specimen.

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[1] Received April 27, 1939.

A distinction between the parasphenoid and basioccipital may be seen ventrally, but in general it is extremely difficult to recognize separate centers of ossification.

4. An enclosed aortic canal occurs in Watson's and Case's specimens but was not observed by Stensiö, who could give little information about the occipital region of *Birgeria.*

5. The spiracle is enclosed in a short canal.

6. Two large median fontanelles occur on the dorsal side, one anterior, the other posterior to the synotic tectum.

Stensiö made certain comparisons with other Actinopteri and with Crossopterygii; Watson carried the comparisons much farther, having better material; Case described a nearly perfect case of the brain and labyrinth, but regarding externals he simply noted a close agreement with Watson. My study adds several details of the soft anatomy, by restoration, and certain interpretations not previously made, while the publication of Romer's (1937) study of the brain case of *Megalichthys* improves greatly the possible comparisons with crossopterygians.

Specific features.—Since the genus and species can not be determined from the brain case alone, the more significant differences between brain case 18565 and that of Watson's paleoniscid A, the nearest to it, may be summarized here (see figures):

1. Aortic canal: tapers caudad in 18565, expands caudad in "A."

2. Second efferent branchial artery: shows no sign of a groove in 18565 but has a definite groove outside the foramen in "A."

3. Groove for lateral radix of dorsal aorta: runs more anteriorly than laterally in 18565, but much more laterally in "A."

4. Spiracular groove: continues far ventrad, nearly to the basipterygoid process, in 18565, but Watson shows none at all on the ventral side of "A."

5. Basipterygoid process: close against ascending process of parasphenoid in 18565, but separated from the ascending process by at least the latter's width in Watson's "A."

There are other less significant differences of proportion of parts, but these show that the specimens are at least specifically distinct. The specimen described here is remarkably good, but not perfect, and it will be impossible to discuss adequately the orbit, myodome, snout, or anterior part of the roof of the cranium. Other parts show well and with little apparent distortion. For the brain and labyrinth see Case (1937).

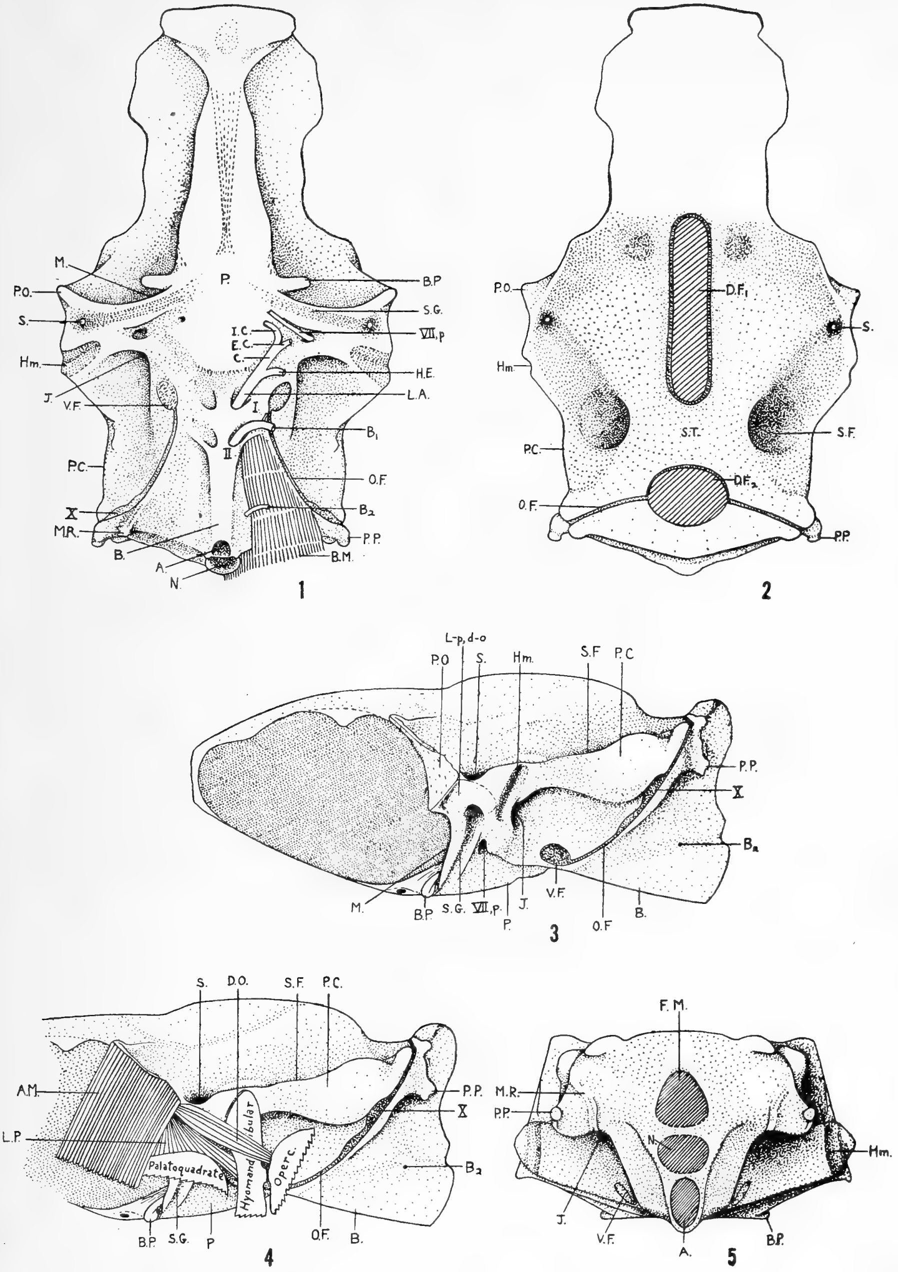
Spiracular region.—A ventral or dorsal view (Figs. 1, 2) shows a large blunt projection on the side of the postorbital region. This is formed, ventrally, by the ascending process of the parasphenoid and is penetrated dorsoventrally by the spiracular canal. The jugular canal passes through more internally, in a nearly longitudinal direction, and a troughlike facet marks the position of the hyomandibular articulation, externally and behind the spiracular canal (Fig. 3). The spiracular canal opens dorsally into a fossa, which spreads caudad to a peculiar deep pit located just above the horizontal semicircular canal. This pit in the present specimen (18565) closely matches the position of the external opening of the spiracle in such a form as *Cheirolepis* (Devonian), and it may be, therefore, that the dorsal course of the spiracular duct was drawn backward. In *Amia*, which likewise has the spiracle enclosed in a canal, there is no such dorsal trough in the neurocranium, and the external opening is directly upward, behind the eye. In *Polypterus*, without an enclosed spiracular canal, there is also no such trough or more posterior pit. Yet the smooth and definite continuity of the trough in the paleoniscid makes it very difficult to imagine any other function than carrying the dorsal part of the spiracular duct.

From the ventral opening of the spiracular canal a narrow but distinct groove runs down and forward, approaching the midventral line. Clearly this carried the lower part of the spiracular duct to the roof of the pharynx.

The anterior face of the postorbital process forms a triangle facing outward, and the roofing bones must have attached to it along its dorsal rim. Judging from *Amia* (Allis, 1897) and *Polypterus* (Allis, 1922) the external division of the adductor mandibulae, or a part of that division, originated on this triangular face. The internal divisions would, of course, have originated on the palatoquadrate. Then the distinct excavation behind this triangle, and lateral to the spiracular canal, housed the origin of the levator palatoquadrati and the smaller, more posterior dilator operculi. The levator palatoquadrati descends fanlike in *Amia* and *Polypterus* to insert on the dorsal edge of the palatoquadrate and anterior face of the hyomandibular. In all probability this arrangement had been established in the paleoniscids, since the amioids and Polypterini are known to represent divergent lines of descent from them. All these muscles are innervated by the trigeminus and are therefore properly jaw muscles. But the dilator operculi reaches back (in *Amia*, *Polypterus*, and other Actinopteri) across the head of the hyomandibular and inserts, usually by a tendon, on the inner face of the operculum. In most of these fishes the distance to reach is considerable, and the muscle is nearly horizontal. In the paleoniscids, however, consideration of the parts involved suggests a fairly short muscle, and there is no evidence of a distinction, at the origin, between this and the levator palatoquadrati. (In the development of the embryo in modern Actinopteri the two arise as one, but take different insertions.) In a previous paper (Eaton, 1939) written before seeing the paleoniscid neurocranium, I suggested that the operculum of "higher" fishes, including Actinopteri, might have been derived from a mandibular type of operculum like that found in acanthodians. If so, the trigeminus innervation of the dilator operculi would be explained easily by supposing that this muscle attached to the operculum when the latter articulated with the mandibular series of bones; it would then have

ABBREVIATIONS FOR FIGURES

A.—Canal for dorsal aorta
A. M.—Adductor mandibulae
B.—Basioccipital
B. M.—Segmental body muscles
B_1, B_2—Branchial efferent arteries 1 and 2
B. P.—Basipterygoid process
C.—Common carotid artery
D. F.$_{1,2}$—Dorsal fontanelles 1 and 2
D. O.—Dilator operculi
E. C.—External carotid artery
F. M.—Foramen magnum
H. E.—Hyoidean efferent artery
Hm.—Facet for hyomandibular
I. C.—Internal carotid artery
J.—Jugular canal
L. A.—Lateral dorsal aorta
L. P.—Levator palatoquadrati
L–p, d–o.—Origin of levator palatoquadrati and dilator operculi
M.—Location of myodome
M. R.—Ridge probably at edge of body muscles
N.—Notochord canal
O. F.—Otico-occipital fissure
P.—Parasphenoid
P. C.—Parotic crest
P. O.—Postorbital process
P. P.—Paroccipital process
S.—Spiracular canal
S. F.—Supraotic fossa
S. G.—Spiracular groove
S. T.—Synotic tectum
V. F.—Vestibular fontanelle
I, II—Probable locations of first branchial articulations
VII, p—Palatine branch of facial nerve
X—Vagus foramen



Figs. 1–5.—Paleoniscid brain case. 1, Ventral aspect, with certain details restored. Length 27 mm. 2, Dorsal aspect, anterior part incompletely preserved. 3, Lateral aspect. 4, Lateral aspect, with certain parts restored. 5, Posterior aspect. All figures about three times natural size.

followed the operculum back in a short migration to the hyomandibular after the hyoid cleft was reduced to a spiracle. The apparent shortness and obliqueness of the muscle in the paleoniscid seems to lend a new support to this idea, and might even have been predicted, since it means that the operculum was, morphologically, nearer to the jaw than in later types. This also shows externally in the apparent relations of the operculum to the dermal jaw bones.

Running back from the facet for the hyomandibular is a strong, uneven parotic crest, which extends as far as the fissure between the otic and occipital divisions of the cranium. This crest is more prominent than in any other fishes, but it is also distinct in Dipnoi (*Neoceratodus*) and Crossopterygii (*Megalichthys;* see Romer, 1937, Figs. 1, 2, 5). Watson (1925) says, "It is difficult to see any reason for the development of the lateral ridge on the otic region, which is, however, quite constant in its occurrence in Actinopterygians, and forms a very marked distinction between these fish and the Osteolepids, Dipnoi and Tetrapods." But it seems to me that the function of the ridge, and its presence in osteolepids and Dipnoi, may be made out quite clearly by considering muscle origins. In each of these groups, but not the tetrapods, several muscles originate behind the hyomandibular on the otic region, and the larger of these, the levator hyoidei and levator operculi (or opercularis) come from just such a ridge. In the Dipnoi, with the operculum and hyomandibular reduced, the muscle from this ridge is the constrictor hyoidei only, which acts in effect as the whole operculum. The parotic crest, then, forms the dorsal boundary of the gill chamber, and is continued back in the form of a paroccipital process or wing, to connect by a sheet of ligament with the supracleithrum and thus furnish also the median wall of the gill chamber. Above the ridge on the neurocranium is a recess for the origin of a part of the epaxial muscles. In Crossopterygii there is a similar ridge, but shorter, in the same place, and with a smooth lateral edge which doubtless provided for the origin of the levator hyoidei and the anterior part of the constrictor. The photograph published in *Time* (April 3, 1939) of a living coelacanth recently caught off the coast of South Africa shows a broad opercular flap extending far back, so that the constrictor (or opercularis) muscle must originate largely on the fascia of the body muscles of the neck, and only a little on the skull. This condition is much like *Neoceratodus*. Above the parotic ridge (*Megalichthys*) is a supraotic fossa, as in Dipnoi, obviously for epaxial muscles. In the paleoniscid there may have been no distinction, at their origin, between the levator hyoidei, going to the hyomandibular, and the levator operculi (the reduced homologue of the constrictor above mentioned), but both must have been present and have originated on the lateral face of the prominent parotic crest. The shiny surface here indicates a large muscle origin. In *Polypterus* the two are scarcely distinct except at their insertions, but in *Amia* they are more so, and the levator operculi apparently forms two separate muscles. In addition, more posteriorly and ventrally in the same region, there are levator muscles for the branchial arches, but these leave no apparent marks on the paleoniscid neurocranium. The only essential difference left, then, between the parotic crest of paleoniscids and that of other fishes seems to be that there was no room for any epaxial muscles to reach forward into the supraotic fossa, mentioned before as the probable dorsal opening for the spiracular duct.

Ventral aspect.—The ventral surfaces of the parasphenoid and basioccipital together have the shape of a cross, the arms of which are the ascending processes of the parasphenoid, each marked by a shallow groove for the ventral end of the spiracular duct. Anterior to the ascending process is the orbit and the short but prominent basipterygoid process, while behind, on each side, is a deep jugular fossa. At the side of the basioccipital occurs a small oval pit, the vestibular fontanelle (Watson) from which the otico-occipital fissure runs posterodorsally (Figs. 1, 3). This fontanelle and fissure mark, evidently, the embryonic distinction between the otic region and the occipital segments added to the cranium behind it. Except during early development such a gap does not occur in the cranium of other fishes. The fissure continues up to the second fontanelle on the dorsal side, behind the synotic tectum (Fig. 2).

The dorsal aorta was enclosed in a canal within a prominent median ridge of the basioccipital (Figs. 1, 5). At the anterior end of the canal there are two pairs of foramina, the first being for the lateral radices of the aorta. A groove leads anterolaterally from each of this first pair of foramina, indicating the course of the arteries. Just in front of the vestibular fontanelle a slight smoothing of the surface suggests the location of the hyoidean efferent; anterior to this the artery would be, of course, the common carotid. A small foramen somewhat mediad from the arterial groove is for the internal carotid; the external carotid would not have entered the cranium, and its further course can not be seen. Returning to the aortic canal, the second pair of foramina would, then, have been for the first branchial efferents. Halfway between these and the posterior end of the aortic canal a very small pair of foramina emerge from the canal, which could only have carried the second branchial efferents, but they seem disproportionally reduced. *Polypterus* is the only living actinopteran that is known to have an aortic canal enclosed in the neurocranium. It differs from the paleoniscid in that only the hyoidean and first branchial efferent arteries enter the canal, the others being behind the limits of the brain case. *Megalichthys* shows a pair of divergent aortic grooves in the base of the cranium, but they are not enclosed, and their union to form the dorsal aorta was more posterior than the end of the cranium. Otherwise, to my present knowledge, Stensiö's (1927) cephalaspid cyclostomes are the only vertebrates in which the aorta was enclosed in the neurocranium.

A distinct oval foramen at the base of each parasphenoid wing, behind the spiracular groove, and lateral to the internal carotid foramen, is evidently for the palatine branch of the seventh nerve. Watson shows a foramen on the side of the otic region, posterodorsal to the vestibular fontanelle and just below the parotic crest, for the ninth nerve, but it is not possible to see this in the present specimen. The surface there is partly disintegrated. The tenth (vagus) nerve evidently emerged from an expanded part of the otico-occipital fissure, also just below the parotic crest; the opening is double.

In *Amia* the first two branchial arches attach to the cranium at points just in front of the proximal ends of their respective efferent arteries. The first one, only, articulates with the cranium in *Polypterus*. The articulating end of the first branchial in each case is forked. The levator muscles for the arches originate laterodorsally to the gill chamber near the vagus foramen. In the paleoniscid it seems probable that the first two arches connected with the basioccipital close to the two pairs of anterior openings of the aortic canal, as indicated in Fig. 1. The location for the first one is indistinguishable, but that for the second seems to show as a faint ligament scar just behind the foramen for efferent artery 1. Presumably the levator muscles originated on the parotic crest just anterior to the vagus foramen and the otico-occipital fissure, thus being in line with the serially homologous levator hyoidei plus levator operculi.

Occipital region.—At the lateral extremity of the occiput occurs, on each side, a prominent knob projecting posteriorly, which has not been described before. This shows most clearly in the posterior view (Fig. 5). Comparison with other Actinopteri identifies it as a paroccipital process, from which a ligament extended to the post-temporal. This comparison also clears up the interpretation of the paroccipital area in other groups of fishes. In Actinopteri, Dipnoi, and Crossopterygii the shoulder girdle is connected with the skull. In Actinopteri the connection is not only by a dermal articulation of the posttemporal with (usually) the epiotic, but also by a ligament running from a ventral process of the posttemporal to a process on the pterotic (teleosts) or opisthotic (more primitive types). The latter process is the one described here as paroccipital. The true opisthotic bone, homologous with that in tetrapods, is a cartilage bone, but apparently in the higher Actinopteri it tends to be crowded out by the dermal pterotic, sometimes erroneously called opisthotic. The process in question, with its ligament (which may ossify) remains in place regardless of which bone may form it.

In Dipnoi (*Neoceratodus*) the parotic crest previously described continues back to connect by a short broad ligament with the supracleithrum, forming the median wall of the gill chamber. In this case the end of the crest from the neurocranium is obviously the paroccipital process, functionally the same as in Actinopteri. It has the same relation to the branchial chamber and to the occipital face of the cranium, besides attaching to the shoulder girdle.

In *Megalichthys* (Romer, 1937, p. 12 and Fig. 5) there occurs a small knob whose morphological relations to the rest of the cranium are much the same as in the paleoniscid; that is, it faces posteriorly in line with the parotic crest, below the supraotic fossa and lateral to the area of greatest muscle attachment. This Romer termed provisionally the paroccipital process, remarking that it was "obviously an important point of attachment." I do not hesitate to identify it with the paroccipital process in the paleoniscid, which carried a ligament to the shoulder girdle, and I infer that it did likewise in *Megalichthys*. The process would be rather out of the way for a branchial arch articulation, as only the first one or two arches probably reached the skull and they would have been fairly near the hyomandibular facets and far more ventral than this process.

In tetrapods the arrangement of parts changes markedly on account of the loss of a shoulder girdle connection with the skull and because the loss of the operculum and the reduction of the hyomandibular eliminates the levator operculi and modifies the levator hyoidei; the latter changes its insertion to the mandible and becomes the depressor mandibulae of amphibians, reptiles, and birds. There is still a parotic crest, essentially as in fishes, above the jugular vein. Any process developed on this crest or near it would be, probably, a new one; such, for example, as the process to which the dorsal arm of the stapes articulates in some reptiles. The term "parotic process" would perhaps be more satisfactory here. It is sometimes, but not always, used.

The area of attachment of muscles to the occipital face of the brain case seems to be as follows: from the dorsal rim down to the sides and lower corners of the foramen magnum and, ventrally, reaching forward nearly as far as the second pair of aortic canal foramina (first branchial efferent arteries); laterally the muscle area reaches to a curious low ridge near the paroccipital process. This ridge probably served for attachment of the external fascia of the epaxial muscles. The area as a whole, including the ventral extension forward, corresponds very closely with that in *Amia*. The posterior end of the parotic crest forms a knob which may have provided the most dorsolateral attachment for the muscle.

Finally, turning to the dorsal aspect of the neurocranium, it is worth noting that the two median fontanelles are practically the same as in the chondrocranium of *Acipenser*, but narrower. *Polypterus* has the anterior one divided by an "epiphysial bar," and lacks the posterior one.

SUMMARY

1. The more important ways in which the paleoniscid brain case shows relationship to that of other Actinopteri are these:

   A. *General.* The skull is tropibasic and from the ventral side the parasphenoid and basioccipital appear as a cross. There is a pair of median dorsal fontanelles, one or both of which usually appear in the chondrocranium of modern Actinopteri. The muscles of the palatoquadrate, hyomandibular, and operculum appear to have been closely similar to those of *Amia* and *Polypterus*. A strong paroccipital process is present, indicating a ligament to the posttemporal as in most modern forms.

   B. Resemblance to *Polypterus*. The aorta occupied a closed canal in the basioccipital; this canal, however, formed a projecting median ridge, absent in *Polypterus*. In connection with *Polypterus* De Beer (1937) shows that its lack of a myodome is evidently secondary, and is correlated with retention of the embryonic hypophysial foramen through the parasphenoid. Such a foramen is lacking in the paleoniscid, and the myodome, as with most other Actinopteri, is well developed.

   C. Resemblance to *Amia*. The spiracle is enclosed in a short canal. In general the features of the brain case are sufficiently near to those of *Amia* to make detailed comparison useful, but this seems to be the only exclusive agreement between *Amia* and the paleoniscid.

D. Resemblance to *Acipenser*. The two dorsal fontanelles of the paleoniscid are far more like those of *Acipenser* than of any others.

E. Special peculiarities. There is a deep supraotic pit connected by a trough with the spiracular canal, and the only interpretation the writer can make is that this carried the dorsal end of the spiracular duct. On the ventral side there is a groove for the spiracle, going toward the middle line. No supraotic fossa for the epaxial muscles is present. The otic and occipital portions are separated by a narrow fissure occupied by cartilage. The parotic crest, for the levator hyoidei and levator operculi, is much more conspicuous than in other Actinopteri. The ridge containing the aortic canal, in the basioccipital, projects down like a keel.

2. Points of particular interest in comparison with Dipnoi and Crossopterygii are these: The parotic crest is shown to be present in the latter two classes also, and to have the same morphological relations to the otic region, gill chamber, and the muscles of the hyomandibular and operculum. The paroccipital process of the paleoniscid is identified not only with that of the Actinopteri but with a similar process in Dipnoi and Crossopterygii, and the relations of the skull to the shoulder girdle are shown to be similar. The greatest contrast of the paleoniscid with these two classes is in its tropibasic skull, but tropibasy was achieved independently in the coelacanths.

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ENTOMOLOGY.—*Notes and descriptions of United States scarab beetles.*[1] LAWRENCE W. SAYLOR, U. S. Bureau of Biological Survey. (Communicated by EDWARD A. CHAPIN.)

Since it is probable that within the near future another supplement will be added to Leng's catalogue of the Coleoptera, I wish to bring to attention certain synonymy as well as additions to knowledge of southwestern scarabs.

Phyllophaga (Phyllophaga) rossi, n. sp. Fig. 6

Male.—Oblong-oval, wider behind; above rufocastaneous and pilose; head and thorax shining, elytra slightly to moderately densely pruinose. Head with the clypeus transverse and flat, its apex truncate and angles rounded; disk with coarse, regularly placed punctures, not pilose; punctures of the front quite large, dense, contiguous, and scabrose, with long erect hair. Antenna 9-segmented, club testaceous and subequal to funicle in length. Thoracic disk with scattered and sparse, umbilicate punctures, each with a very long erect hair; these punctures on the apical half of the disk are nearly twice as large as those on the basal half; lateral margin coarsely crenate and with very long cilia; basal margin obsolete; front thoracic angles acute, hind angles obtusely angulate. Elytra with very fine and moderately dense punctures, without traces of striae except for the weakly indicated sutural striae; punctures with very small, procumbent hairs; there are longer and erect hairs scattered along the scutellar area and at the apex, the lateral margins also have a dense fringe of cilia. Pygidium convex, polished, with moderately dense, coarse, umbilicate punctures, at the sides and along the base the punctures are smaller and contiguous; disk with a moderately dense covering of small semierect hairs and also numerous very long erect hairs. Abdomen flattened, faintly concave at center and with sparse, fine punctures; fifth sternite somewhat rugose at middle and with much coarser punctures at sides, apical half varying from flat to slightly longitudinally sulcate; sixth sternite short, transversely impressed, basal margin slightly carinate, center of disk with a short longitudinal sulcus. All claws with a sharp median tooth, base hardly dilated. Hind tibial spurs free; first tarsal segment shorter than the second. Except for submarginal rows of ciliate punctures, the entire surface of the posterior femur is highly polished and impunctate. Length 12–13.5 mm. Width 6–7 mm.

The *holotype* and *paratypes* are from Patagonia, Ariz., and were collected in July 1937 by E. S. Ross. I take pleasure in naming the species after Mr. Ross, of the University of California, to whom I am indebted for many favors and specimens in the past. Two additional paratypes taken at the same time and place by M. A. Cazier also are in my collection. The type will be placed in the United States National Museum on permanent loan, and one paratype will be deposited in the collection of Dr. M. A. Sanderson, of Fayetteville, Ark.

This species runs to Group XV of Horn's tables, but it is not at all close to any of the included species, or to any other known from the United States. Its closest relative appears to be the Mexican *P. porodera* Bates, known from Guanajuato and Peras, but *P. rossi* differs from that species in many details among them the nonelevated and nonsinuate clypeal apex, the 9-segmented antennae, and the abdominal characters.

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[1] Received April 25, 1939.

Phyllophaga submucida LeConte

Phyllophaga submucida LeConte, Journ. Acad. Nat. Sci. Philadelphia **3:** 260. 1856.

I have three specimens of this species from Rancho La Golondrina, Rio Sabinas, Coahuila, Mexico, collected June 2, 1938, by Rollin H. Baker of College Station, Tex., and very kindly presented to me by him. Not previously recorded outside of the United States.

Phyllophaga torta LeConte

Phyllophaga torta LeConte, Journ. Acad. Nat. Sci. Philadelphia **3:** 239. 1856.
Lachnosterna dampfi Arrow, Ann. Mag. Nat. Hist., **11:** 148. 1937. (New synonymy.)

G. J. Arrow, of the British Museum, has kindly compared Mexican and Texan examples of this species with the types of *P. dampfi* and reports that the two are the same. Thus the known range of *P. torta* is extended a good distance into Mexico, where it has not previously been recorded.

Phyllophaga ignava Horn

Phyllophaga ignava Horn, Trans. Amer. Ent. Soc. **15:** 280. 1887.

I have a specimen of this species from Rancho La Golondrina, Rio Sabinas, Coahuila, Mexico, June 2, 1938, collected by R. H. Baker, and another from Nuevo Leon, Mexico, June. Not previously recorded from Mexico.

Phyllophaga crinita (Burmeister)

Trichestes crinita Burmeister, Hand. Ent. (2) **4:** 359. 1855.

I have a good series of this species taken at Buena Vista, Coahuila, Mexico, July 7, 1938, by R. H. Baker, and also some from Monterrey. Recorded by Bates from Mexico.

Phyllophaga vetula Horn

Phyllophaga vetula Horn, Trans. Amer. Ent. Soc. **14:** 274. 1887.
Lachnosterna longipilosa Bates, Biol. Centr. Amer. (2) **2:** 209. 1888. (New synonymy).

I have cotypes of Bates's species, and they are the same as *P. vetula.* The range of *P. vetula* is thus extended into Mexico, where the species has not been previously recorded.

Phyllophaga lenis Horn

Phyllophaga lenis Horn, Trans. Amer. Ent. Soc. **14:** 287. 1887.
Lachnosterna anodentata Bates, Biol. Centr. Amer. (2) **2:** 208, 405. 1888. (New synonymy.)

I have compared cotypes of Bates's species with *lenis* and the two are the same.

Phyllophaga fucata Horn

Phyllophaga fucata Horn, Trans. Amer. Ent. Soc. **15:** 278. 1887.
Phyllophaga linsleyi Saylor, Pomona Journ. Ent. and Zool. 1936. (New synonymy.)

Phyllophaga (Tostegoptera) lanceolata (Say)

Phyllophaga lanceolata Say, Journ. Acad. Nat. Sci. Philadelphia **3:** 242. 1824.
Phyllophaga lanceolata arizonae Von Bloeker, Bull. Southern California Acad. Sci. **35:** 4. 1936.

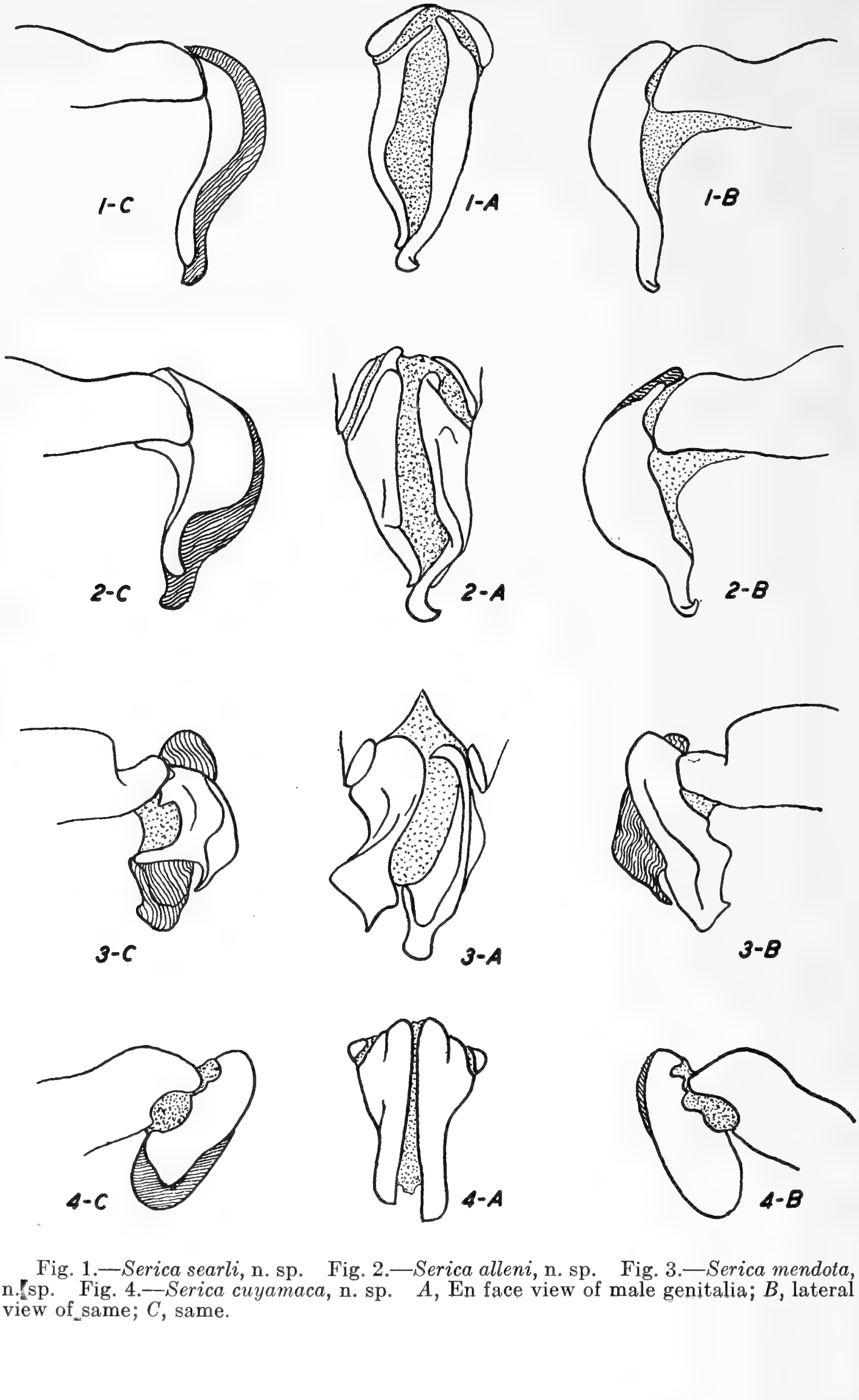

Fig. 1.—*Serica searli*, n. sp. Fig. 2.—*Serica alleni*, n. sp. Fig. 3.—*Serica mendota*, n. sp. Fig. 4.—*Serica cuyamaca*, n. sp. *A*, En face view of male genitalia; *B*, lateral view of same; *C*, same.

Phyllophaga grisiana Von Bloeker, *l. c.*, p. 5.
Phyllophaga cazieri Von Bloeker, *l. c.*, p. 6.

I have dissected paratypes of all of Von Bloeker's "species" and find that there is nothing to validate the names, even subspecifically. In Von Bloeker's description of *P. cazieri* he says: "The golden yellow scales and globosity of the female readily distinguish the species." It is well known that in species (e.g., *Thyce fieldi* Fall) ordinarily clothed with white scales the vestiture may frequently be yellow. This color variation, however, does not have subspecific or even racial significance. Variability in gibbosity of the female of any species having short or obsolete wings also must be recognized. Striking evidence of this and of the color variation may be seen in almost any large series of *P. lanceolata* even if collected at the same time and place. The male genitalia of all the forms described by Von Bloeker are exactly like those of *P. lanceolata,* as indeed his sketches show.

Phyllophaga chippewa, n. sp. Fig. 5

Male.—Elongate-oval, slightly wider behind, above polished, nearly or quite glabrous. Clypeus and front very densely, somewhat coarsely punctate, clypeus flat, apex broadly and not deeply emarginate and hardly reflexed, angles broadly rounded. Antenna 10-segmented, club a little longer than the funicle. Puncturation and shape of thorax, elytra, and pygidium and abdominal characters exactly as in *P. knochi* Horn. Fixed spur of the hind tibia three-fifths as long as the free spur. Tarsal claw with the tooth long and sharp, slightly more apical in position than in *P. knochi.* Length 18 mm. Width 9 mm.

The unique male *type* bears the data: "Schley, Minn., Chippewa National Forest, taken by L. W. Orr's collection crew on June 13, 1935 from Quaking Aspen (*Populus tremuloides*), Unit 1, Plot 3." The type was presented to the United States National Museum by R. H. Nagel and is deposited in that collection.

P. chippewa belongs in Horn's Group IX and is with difficulty separable externally from *P. knochi* Horn; the most obvious external difference between the two is the slightly more apical tarsal claw in the new species. The male genitalia are quite different, those of *chippewa* approaching closely the groups having bilaterally symmetrical claspers while *knochi* is representative of those species having strongly asymmetrical genitalia.

Serica laguna Saylor

Serica laguna Saylor, Pomona Journ. Ent. and Zool. **27**(1): 1. 1935.

This species was described from a unique male, and I have since seen two males from Idyllwild, Riverside County, Calif., collected July 4, 1929.

Serica elongatula Horn

Serica elongatula Horn, Trans. Amer. Ent. Soc. **3**: 77. 1870.

This species is one of the rarer forms of the genus; I have a goodly series collected by W. C. Reeves, at light, on May 26, 1937, at Independence, Inyo County, Calif. The fact that the species inhabits this semiarid region seldom visited by collectors may account for its rarity in collections.

Dichelonyx vicina Fall

Dichelonyx vicina Fall, Trans. Amer. Ent. Soc. **27**: 291. 1901.
Dichelonyx deserta Hopping, Can. Ent. **63**: 236. 1931. (New synonymy.)

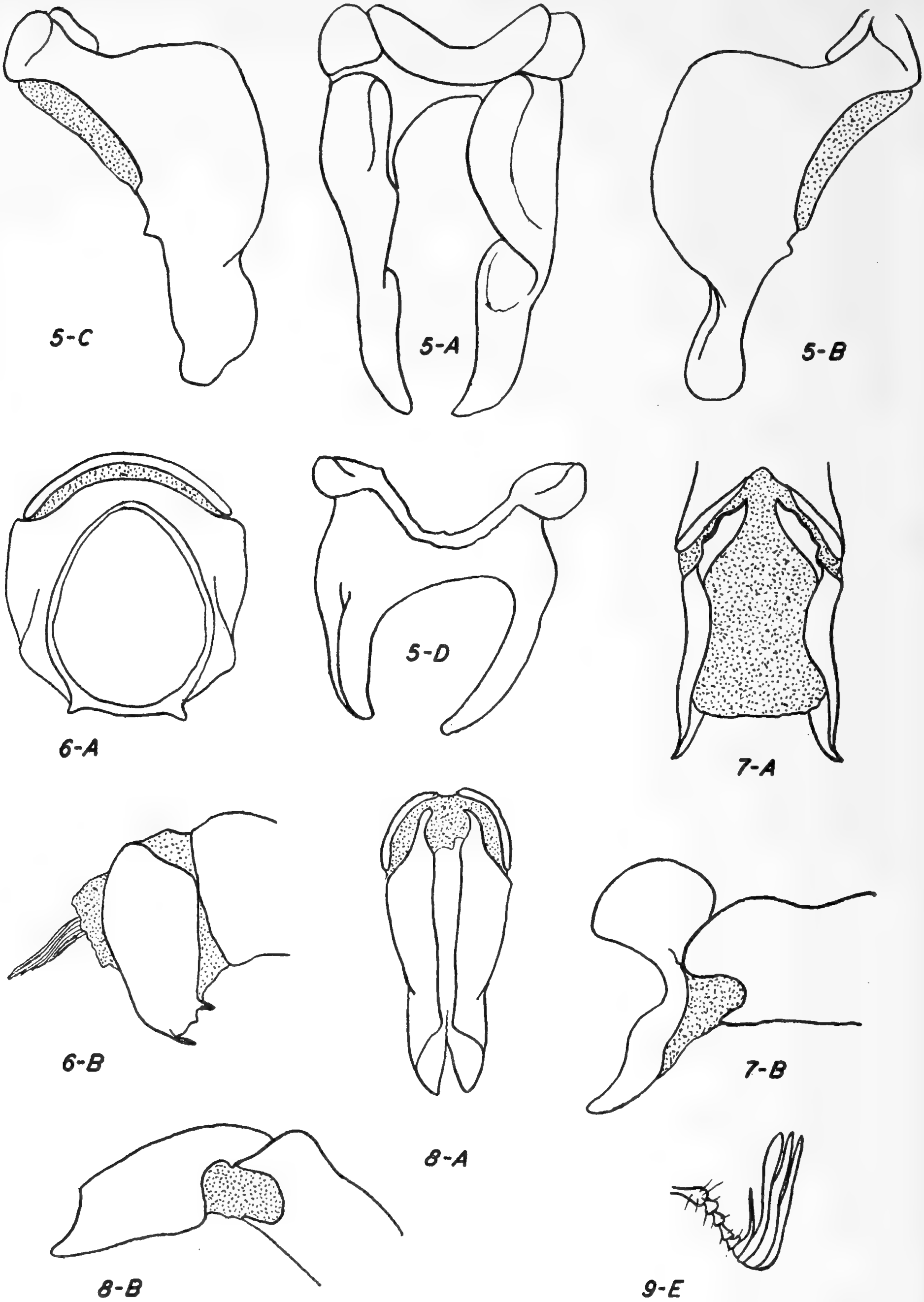

Fig. 5.—*Phyllophaga chippewa*, n. sp. Fig. 6.—*Phyllophaga rossi*, n. sp. Fig. 7.—*Serica chicoensis*, n. sp. Fig. 8.—*Serica sandiegensis*, n. sp. Fig. 9.—*Serica mendota*, n. sp. *A*, En face view of male genitalia; *B*, lateral view of same; *C*, same; *D*, dorsal view of male genitalia; *E*, male antenna.

The examination of paratypes of both of Hopping's species indicates that *D. deserta* is a straight synonym of *vicina;* the dark hairs on the head that Hopping mentions in the description are white hairs that had been covered with grease, as degreasing showed.

Dichelonyx vicina columbiana Hopping

Dichelonyx columbiana Hopping, Can. Ent. **63**: 236. 1931.

D. columbiana is probably valid as a northern subspecies of *D. vicina*, since it has more coppery reflections on the elytra and thus can usually be picked from a series of the typical form.

Diplotaxis falli Saylor

Diplotaxis falli Saylor, Pan-Pacific Ent. **11**: 35. 1935.

This species was described from two males from Victorville, Calif. I have recently seen specimens from Coalinga, Calif., collected May 14 by M. A. Cazier and in his collection. Through Mr. Cazier's kindness I now have the female represented in my collection.

Pachyplectrus laevis LeConte

Pachyplectrus laevis LeConte, Trans. Amer. Ent. Soc. **5**: 54. 1874.

I have two specimens of this rare and little-known species, both collected in Mason Valley, San Diego, Calif., on March 27. Early spring emergence may account in part for its apparent rarity.

Serica alleni, n. sp. Fig. 2

Male.—Piceous to piceocastaneous, moderately shining, apparently glabrous above except for a few short elytral hairs. Clypeus with moderate to coarse, rugose punctures, clypeal suture hardly indicated; apex truncate, widely and shallowly emarginate, lateral margins entire. Front with coarse irregularly placed punctures, vertex impunctate. Antenna castaneous, club slightly longer than the funicle. Thorax moderately densely punctate, with a small median impunctate area. Elytra with coarse, irregularly placed punctures.

Female.—Slightly more robust, antennal club a little shorter, and abdomen strongly convex in lateral view, but otherwise similar to male. Length 8–9.5 mm. Width 5–5.5 mm.

The *holotype* male and *allotype* female are from Lake Arrowhead, Calif. (Saylor collection), collected by Paul Allen at light on June 30, 1932, and will be deposited on loan in the U. S. National Museum. Ten paratypes with the same data remain in the Saylor collection. The genitalia of *alleni* are close to *laguna* Saylor, but are distinct, and the body in the present species is more elongate and less coarsely punctate.

Serica mendota, n. sp. Figs. 3 and 9

Male.—Piceocastaneous, elytra strongly pruinose, clypeus and elytra with a few scattered hairs. Clypeus polished, slightly tumid, disk smooth at sides of apex, center with coarse and dense punctures; apex truncate, with the center margin reflexed and (viewed from directly in front of the clypeus and on a plane with the clypeal surface) raised into a moderate peak, lateral angles rounded, the sides entire. Front pruinose, with moderately dense punctures. Antenna 9-segmented, testaceous, club of $3\frac{1}{2}$ segments, the fifth segment produced inwardly into a short spine and the sixth segment produced into an antennal leaf a little more than one-half as long as the seventh;

segments 7–9 inclusive slightly longer than the entire antennal stem. Thoracic and elytral puncturation very fine but obscured by the pruinosity of the surface. Abdomen in lateral view somewhat flattened. Length 8–8.5 mm. Width 4–5 mm.

The *holotype* male, also numerous *paratypes*, are from "Mendota, Calif., collected by G. T. York on April 10, 1936, and May 1, 1937" and are in the United States National Museum. Designated paratypes are also in the Saylor collection.

This species is abundantly distinct from all other described species in our fauna by the 4-segmented antennal club, shape and puncturation of the clypeus, and the male genitalia.

Serica chicoensis, n. sp. Fig. 7

Male.—Light buff-testaceous, head and thorax more brownish, surface faintly pruinose, glabrous except for a few scattered and inconspicuous short hairs on the elytra, sides of thorax, and clypeus. Clypeus tumid, densely and finely punctate, apex moderately sharply reflexed, lateral margins with a faint indication of a notch. Front finely, not densely punctate, vertex nearly impunctate. Antenna testaceous, club subequal to funicle. Thorax very finely and densely punctate, lateral margins ciliate. Elytra very sparsely and irregularly punctured between the lightly-impressed striae. Pygidium lemon-yellow, finely densely punctate, with short erect hair, and some longer intercalated hair before the apex. Length 7.5 mm. Width 4 mm.

The unique male *holotype* is in the United States National Museum and bears the data "Chico, California, collected June 24, 1937 by F. W. Turner." The genitalia are quite distinct from those of any described species of the genus.

Serica sandiegensis, n. sp. Fig. 8

Male.—Elongate, piceocastaneous above, faintly shining and with a very light pruinose bloom, glabrous except for a few scattered hairs on the elytra. Antennal club subequal to funicle. Clypeus slightly tumid at middle, disk finely and very densely punctate; apex truncate, faintly, widely and shallowly emarginate at the center, the angles narrowly rounded, lateral margins entire. Front sparsely and somewhat regularly punctate. Thorax finely and entirely punctate. Elytra moderately densely punctate between the lightly impressed striae. Pygidium with short erect hair. Abdomen slightly convex in lateral view. Claws cleft, the lower tooth much the widest of the two. Length 7.5 mm. Width 4 mm.

The *holotype* male is from "San Diego, Calif., collected by Ricksecker" and is deposited in the Casey collection at the United States National Museum; a paratype male from "San Diego, Calif. (Saylor collection)" remains in my collection. The symmetrical genitalia are not closely allied to those of any other described species in the country. Two other specimens in the Saylor collection, a pair from "San Diego, Calif., El Monte Oaks," are apparently this species though possessing slight differences which make it seem advisable to leave them without type designation. In external characters they are somewhat different, since the color is light lemon-yellow, the clypeus is more acuminate apically and the lateral edge of the clypeus is slightly though distinctly notched. The color may have been in part due to their specimens being collected in alcohol, though this is doubtful; the lateral clypeal notches are known to be somewhat variable within a species. Larger series of these El Monte Oaks specimens may well indicate a closely allied but distinct species based on the color and clypeal differences as well as the slightly different male genitalia.

Serica searli, n. sp. Fig. 1

Male.—Piceocastaneous, robust, slightly shining, elytral apex slightly pruinose, dorsal surface apparently glabrous. Clypeus slightly tumid, disk with very dense and coarse punctures; lateral margins rounded and slightly notched near the angles; apex widely and very shallowly emarginate. Front with irregularly placed, somewhat dense punctures. Antennal club subequal to funicle. Thorax with coarse, dense punctures, those punctures of central basal area the most coarse and those areas near the hind angles the most densely punctate. Elytra with coarse, moderately dense punctures. Pygidium with dense and very coarse punctures in basal two-thirds, the punctures a little more fine apically.

Female.—Antennal club shorter than funicle, otherwise similar to male. Length 7.5–8 mm. Width 4.5–5 mm.

The *holotype* male and *allotype* female (Saylor collection) are from "Idyllwild, Riverside, County, Calif., collected April 28, 1928, by C. C. Searl" and will be deposited on loan in the United States National Museum. A male paratype from the same locality, collected on June 24, 1929, remains in the Saylor collection. *S. searli* is closest to *S. laguna* Saylor, but the male genitalia will readily separate the two.

Serica cuyamaca, n. sp. Fig. 4

Male.—Dull piceocastaneous, with slight pruinose vestiture, the dorsal surface with sparse, erect, and scattered hair. Clypeus slightly tumid, very coarsely and rugosely punctate; lateral margins entire, apex moderately reflexed widely and shallowly emarginate, the angles rounded. Front opaque, with fine and moderately dense punctures. Antenna testaceous, club slightly longer than the funicle. Thorax with very fine, dense, and regularly placed punctures. Puncturation of elytra very fine, strial intervals impunctate or with a few scattered and fine punctures. Pygidium very finely, regularly, moderately densely punctate. Abdomen convex, with moderately dense, subprocumbent hairs.

Female.—Apparently the same in all essential characters as the male. Length 7–8.5 mm. Width 4–5 mm.

The *holotype* male and *allotype* female (Saylor collection) are from "Cuyamaca, San Diego County, collected by Albert Watson on July 13, 1934" and were presented to me by the collector; these types will be deposited on loan in the collections of the United States National Museum. A paratype with the same data remains in the Saylor collection. *S. watson* Saylor is the closest described relative of *S. cuyamaca,* and the two may be most readily separated through the male genital characters.

ANTHROPOLOGY.—*A new type of artificial cranial deformation from Florida.*[1] T. Dale Stewart, U. S. National Museum.

In his *Anthropology of Florida* (1922) Hrdlička states that—

> The majority of Floridian skulls show artificial moulding. There is but one type of this: the fronto-occipital flattening; but in instances the frontal parts have been so little affected that the occipital compression alone is perceptible.
>
> The degree and frequency of the deformation differ from locality to locality, both diminishing in general, it appears, from north to south. . . . (pp. 83–85)

A review of the material available to Hrdlička in 1922 shows clearly that the majority of skulls was from the northern part of the State, especially the Gulf coast portion. Newer collections from the central and southern parts of the peninsula contain very few deformed skulls. From this fact, together with the evidence of recent archeological investigations, it seems evident that fronto-occipital cranial deformity, like many another culture trait (Stirling, 1936), represents a late culture thrust into the State from Georgia, Alabama, Mississippi, and elsewhere. Further analysis of cranial deformity in the Southeast, in connection with associated traits, will undoubtedly indicate the particular culture center from which this custom spread to Florida.

In contrast to the fronto-occipital type of deformity characteristic of the skull collections from north and northwest Florida is a new type from southern Florida with which this report is primarily concerned. This new type, for which I propose the name "obelionic,"[2] neither fits into the usual classifications of cranial deformation nor shows relationship outside of Florida. For these reasons it seems desirable to record briefly the circumstances of its discovery.

In 1929 Mr. S. H. McCrory, of the U. S. Bureau of Public Roads, informed the Division of Physical Anthropology, U. S. National Museum, of the discovery of human remains near Canal Point, Fla. A letter to Mr. Howard Sharp, editor of *The Everglades News*, elicited the information that the bones had been exposed by an excavating machine on the property of the Southern Sugar Co. Mr. C. Greenwood, the company's superintendent of cultivation, subsequently sent in a collection of the bones, including three reconstruct-

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[1] Part of a paper read at the tenth annual meeting of the American Association of Physical Anthropologists, Philadelphia, April 4, 1939. Published by permission of the Secretary of the Smithsonian Institution. Received April 26, 1939.

[2] Von Bonin has used this term in connection with a similar type of deformity occurring in the Pueblo area (Southwestern United States), but in that case the term "lambdoid" has precedence and is well established in the literature.

able undeformed skulls, which Dr. Hrdlička described as "in all probability the type of the pure Calusa."[3]

In response to a request for additional material a second shipment was received, which is described as follows in Mr. Greenwood's letter of February 7, 1930:

> . . . it gives me pleasure to remit to you two packages of additional remains. [The contents of] one of these was collected from the same location as that of the previous remittance from which the Calusa type came. [The contents of] the other package was dug out of a shell mound from another part of the plantation, several miles distant from where the Calusa type was discovered.

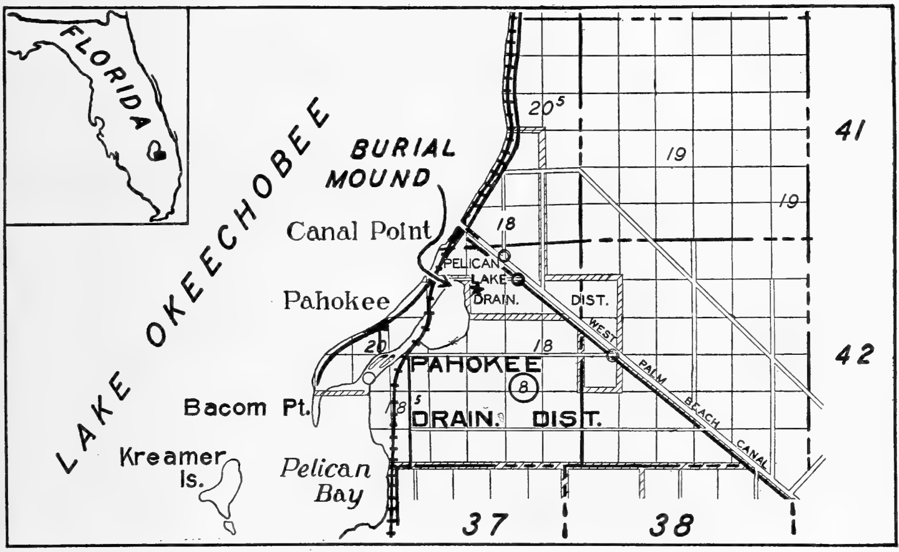

Fig. 1.—Location of shell mound containing deformed skulls.

There is nothing in the correspondence to show that Dr. Hrdlička saw this material when completely reconstructed, for at the time the second shipment was acknowledged (February 19, 1930) he said merely: "We have reconstructed in part about seven of the skulls from the first locality and they all show the same type. . . " Perhaps as a result of this statement all the material constituting the second shipment was accessioned together, with no indication that it was derived from two sites.

Recently I had occasion to examine this material and was surprised to find a number of the skulls (10) exhibiting a strange kind of de-

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[3] Letter to Mr. Greenwood of January 17, 1930. The contour of one of these (345768) is shown in Fig. 2.

formity. Upon segregating the deformed specimens it was at once apparent that they were all shell encrusted, whereas the remainder of the collection under this accession (with one exception) showed evidence of burial in "muck." Then it was that Greenwood's statement regarding two sites, several miles apart, was noted in the correspondence.

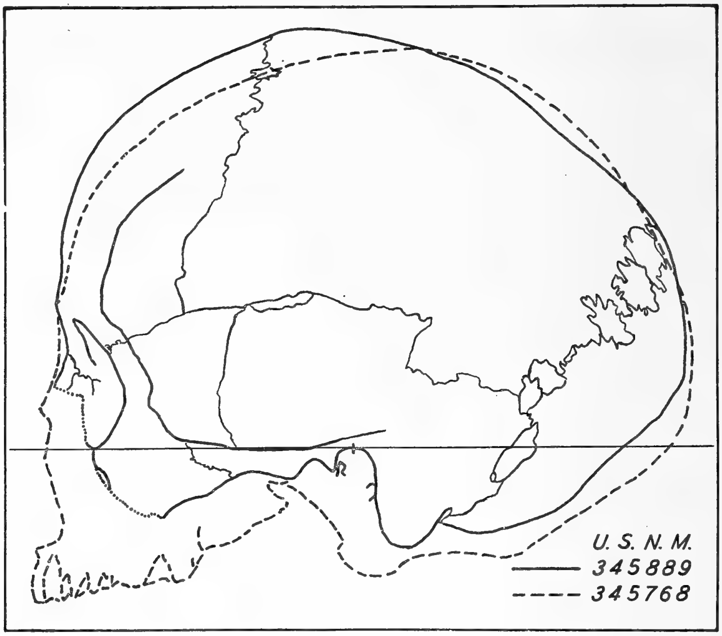

Fig. 2.—Superimposed lateral contour drawings of deformed (345889) and undeformed (345768) skulls. About one-half natural size.

I immediately wrote to Mr. Greenwood, asking for the precise location of the shell mound (second site). Although Mr. Greenwood had left the sugar company's employ in 1930, Mr. W. P. Jernigan was able to give me the desired information. A map (Fig. 1) is supplied to aid in understanding the following extract from Mr. Jernigan's letter of January 2, 1939:

> The first material . . . sent you I believe came from the southwest corner of Section 14, Township 42, South; Range 37, East. It was found about six feet below the surface when a ditch was dug on the section line. The surrounding material was the same type as all the soil in this locality, i.e., muck or peat. . . .
>
> The other specimens came from a point about one third of a mile from the northwest corner of Section 10, Township 42, South; Range 37, East, and about 200 feet from the north line of the section. The mound was of shell and marl and the bones were in the upper three or four feet. It is located on

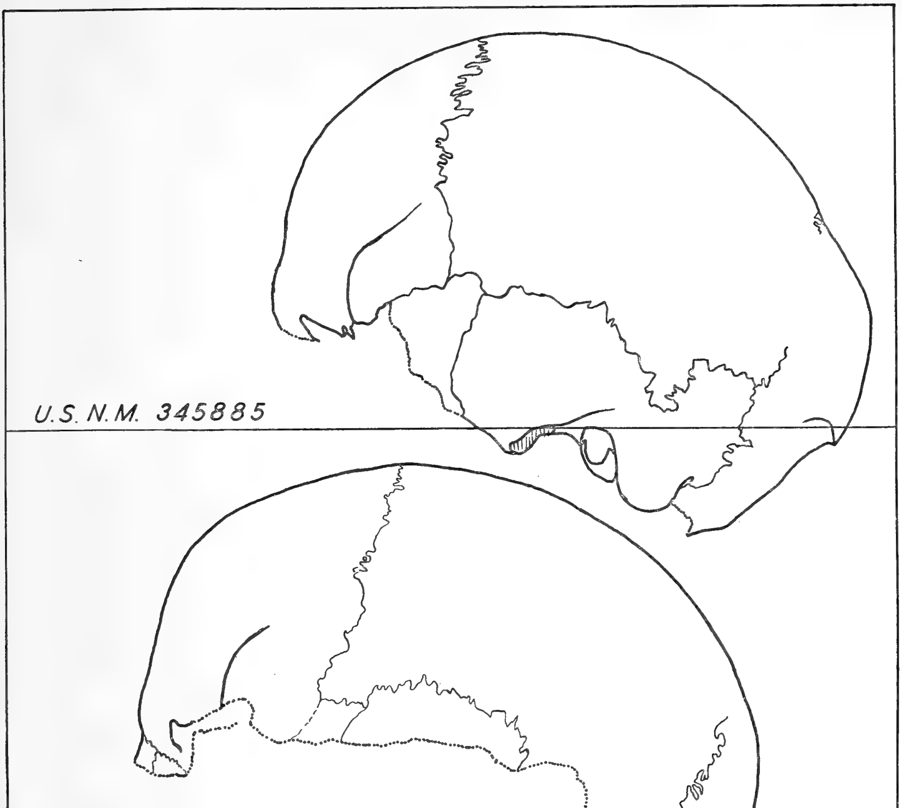

Fig. 3.—Lateral contour drawings of three skulls with obelionic deformation. About one-half natural size.

the edge of a ridge of soft rock and marl which extends for several miles in a general northeast and southwest direction. . . . Most of the material has been used for road building.

On my request for potsherds from the site of the shell mound, Mr. Jernigan sent in a collection from the surface of a canal bank located on the north section line of Section 10. All of these sherds are of plain undecorated ware characteristic of the area (Stirling, 1935), and none shows shell encrustation, so the culture relationship remains undetermined.

As for the skulls, the characteristic alteration in lateral contour is illustrated by line drawings in Figs. 2 and 3.[4] Fig. 2 shows one of the deformed skulls (345889) superimposed on an undeformed skull from the same locality (site 1). The deformation occurs between bregma and lambda, and this area appears as a plane inclined approximately 30° to the horizontal. Compensatory changes include a broadening of the vault and bulging of the forehead. Presumably some recovery from the original degree of deformity has taken place during adult life. In all cases the deformation has produced symmetrical changes. Unfortunately, the specimens with deformation are all fragmentary and anthropometric comparisons can not be instituted.

The National collections contain at least one specimen with obelionic deformation from another locality. This skull (293090) was collected by Dr. Hrdlička in 1916 on Demere Key, Pine Island Sound (West coast). Here, as at Canal Point, the bone is encrusted with coquina, and the culture is unknown.

These finds raise a number of questions that can not be fully answered at the present time: (1) How was this deformity produced? (2) Did this type of deformation have an independent origin in Florida? (3) Is it limited to southern Florida? (4) Does it represent a population older than the Calusa? Obviously, before most of these questions can be answered satisfactorily it will be necessary to locate and carefully excavate other sites containing these deformed skulls.

In view of the fact that the answer to the first question will always remain speculative, I may be permitted an opinion thereon. Theoretically, except where deformation is caused simply by the weight of the head upon a hard surface, some intentional pressure must be exerted to hold the head against the deforming surface. In the present case the point of counter pressure appears to be the chin or some part of the anterior trunk. Perhaps, therefore, the child was bound to the cradleboard in such a way that the head was pressed against an

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[4] I am indebted to Mr. Georg K. Neumann for making these drawings on his stereograph (Schwarz).

inclined endpiece. This view seems more logical than that which envisions a bandage passed under the chin, for the simple reason that the latter mechanism would have deformed the jaw also, and—there is no evidence of this in the present collections.

As already indicated (footnote 2), the so-called "lambdoid" type of deformity in the Pueblo area of the Southwest is somewhat similar to the obelionic type. The difference is mainly in the degree of inclination of the plane of flattening. In the lambdoid type this plane is steeper, being about 50–60° to the horizontal. This being the case, the flattened plane does not extend so far forward as bregma, and on the other hand involves the occiput down to about inion. The method of production is unknown but is probably the same as that suggested above for the obelionic type.

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

CHEMICAL SOCIETY

506TH MEETING

The 506th meeting was held in the auditorium of the Cosmos Club on Thursday, January 12, 1939, President KRACEK in the chair. This meeting was the 55th annual meeting of the Society and the 45th annual meeting of the Washington section of the American Chemical Society. After the reading of the minutes of the preceding meeting the annual reports of the Secretary and the Treasurer, followed by that of the Auditing Committee (W. H. Ross, chairman, P. H. GROGGINS, C. E. WHITE), were read and accepted. The following committees were appointed to serve during 1939: Communications: S. B. HENDRICKS (chairman), M. M. HARING (deputy chairman for divisional meetings), L. W. BUTZ, MICHAEL FLEISCHER, G. E. HILBERT, J. I. HOFFMAN, HANS LINEWEAVER, R. S. MCBRIDE, S. N. WRENN. Entertainment: S. T. SCHICKTANZ (chairman), M. A. BRADSHAW, S. BRUNAUER, W. L. HALL, E. L. JACKSON, FLORENCE B. KING, W. B. KUNZ, W. L. LAMAR, O. H. LOEFFLER, J. MCLAREN, C. M. SMITH, E. R. SMITH, W. J. SVIRBELY,

H. G. WISEMANN. Membership: J. J. FAHEY (chairman), E. O. HAENNI, ELIZABETH HEALY, W. B. HOLTON, H. W. HOWARD, R. J. MAWHINNEY, C. R. NAESER, R. D. REMLEY, N. K. RICHTMYER, W. G. SCHLECHT, L. A. SHINN, LOUISE STANLEY, J. B. TOMLINSON, C. E. WHITE, K. T. WILLIAMS. Budget: J. H. HIBBEN (chairman), R. M. HANN, E. R. SMITH, and NORMAN BEKKEDAHL (ex officio). Finance and Investment: RALEIGH GILCHRIST (chairman), M. X. SULLIVAN, E. G. ZIES.

The Society was addressed by the retiring President, NATHAN L. DRAKE, who spoke on *Cerin and friedelin, two pentacyclic triterpenoids.* The speaker discussed the results of a long series of researches designed to elucidate the structures of these compounds, particularly in relation to the structures of the polyterpenoids in general. The research papers are published in recent volumes of the Journal of the American Chemical Society.

507TH MEETING

The 507th meeting was held in the auditorium of the Cosmos Club on Thursday, January 26, 1939, President KRACEK presiding. This was a special meeting, addressed by F. LONDON, of the Institut Henri Poincaré, Paris, who spoke on *Supraconductivity in aromatic molecules.* The speaker discussed the nature of the chemical bond, with particular application to aromatic molecules.

508TH MEETING

The 508th meeting was held in the auditorium of the Cosmos Club on Thursday, February 9, 1939, President KRACEK in the chair. After the reading of the minutes it was announced that the Hillebrand Prize Award for 1938 was to be presented at the March meeting to RALEIGH GILCHRIST and EDWARD WICHERS for their work on a new system of analytical chemistry for the platinum metals. The Society was then addressed by Professor HELLERMAN, of the Department of Physiological Chemistry, Johns Hopkins University:

LESLIE HELLERMAN: *Some recent developments concerning the constitution and mode of action of enzymes.*—Enzyme chemistry is a crossroads—a meeting ground for several fields of chemistry and of biology, nutrition, and medicine. Enzymatic mechanisms are concerned with most of the reactions of biochemistry, and modern work is developing some surprises. The enzymes that recently have been most intensively studied are found to be protein in character. This seems to have defined sharply the proposition that enzymatic catalysis is catalysis superimposed upon the complexities of protein chemistry; it also provides a more rational basis for the control of enzyme actions in experimental work. The older speculations regarding the nature of enzymes are finding limited support in current investigations upon the enzymes and coenzymes ("pyridine and flavin nucleotides," pyrophosphorylated vitamin B_1, adenosine phosphates) concerned in biological oxidation-reductions. Modern work seems to be clarifying the role of the coenzymes; also the nature of the catalysts concerned with the action of oxygen. The several recognizable factors underlying the control of biological catalysis are well illustrated on the one hand by the process of formation from their inactive precursors of the crystallizable protein-enzymes of digestion, and on the other by the behavior of certain hydrolytic enzymes and other principles with respect to reversible chemical processes, such as oxidation-reduction and probably metal-complex formation. The nature of enzyme specificity is well illustrated by the arginine-splitting enzymes. (*Author's abstract.*)

RAYMOND M. HANN, *Secretary*

Obituaries

JACOB GOODALE LIPMAN died at New Brunswick, N. J., on April 19, 1939. He was born at Friedrichstadt, Russia, November 18, 1874, but spent his early youth on a New Jersey farm. His undergraduate studies were made at Rutgers University, where he obtained his B. S. degree in 1898. For the next two years he served the New Jersey Experiment Station as assistant chemist and then entered Cornell University for his graduate studies, receiving his Ph. D. degree in 1903. For his distinguished services to agriculture he was awarded an honorary degree of D. Sc. by Rutgers University in 1923 and an honorary Ph. D. by the Catholic University of Santiago, Chile, in 1930.

After serving his alma mater in various capacities as soil chemist and bacteriologist, he was appointed director of the New Jersey Agriculture Experiment Station in 1911 and dean of agriculture in 1915, both of which positions he occupied at the time of his death. Although charged with heavy administrative duties, Dr. LIPMAN not only remained actively engaged in research but found time to serve as editor-in-chief of *Soil Science,* a journal he founded in 1915. He was editor also of the Agricultural Series published by John Wiley & Sons and contributing editor of *Annales Agronomiques, Pennsylvania Farmer, Chronica Botanica,* and *Wissenschaftliches Archiv für Landwirtschaft.*

Dr. LIPMAN's publications constitute a long list of technical papers on soils, soil bacteriology, and agronomy. He was a corresponding member of the Swedish Royal Academy of Agriculture, French Academy of Agriculture, and the Czechoslovakian Academy. In 1922, 1924, and 1926 he was a delegate to the International Institute of Agriculture at Rome and in 1927 was president of the International Congress of Soil Science. He held membership in the Academy and the following organizations: American Chemical Society, American Society of Agronomy, Association of Official Agricultural Chemists, American Society of Bacteriology, American Public Health Association, Association of Land Grant Colleges and Universitites, American Academy of Political Science, American Academy of Arts and Sciences, Société de Chimie Industrielle, Reale Accademia dei Georgofili di Firenze, and International Society of Soil Science.

JOSEPH GRINNELL, director of the Museum of Vertebrate Zoology and professor of zoology at the University of California in Berkeley, died at his home in Berkeley, Calif., on May 29, 1939. Dr. GRINNELL was born on February 27, 1877, at Old Fort Sill, Indian Territory, in what is now Oklahoma, where under frontier conditions he lived during childhood. He attended high school in Pasadena, Calif., and in 1897 received an A.B. degree from Throop Polytechnic Institute. This was followed by graduate work at Stanford University for which he received the degrees of A.M. in 1901 and Ph.D. in 1913. He was an instructor at Stanford from 1900 to 1902 and taught at Throop from 1903 to 1908, during the last three years as professor.

To his colleagues and students of this present day JOSEPH GRINNELL is associated always with the Museum of Vertebrate Zoology, founded at the University in Berkeley in 1908 by Miss ANNIE M. ALEXANDER and supported generously by her in the years that have followed, both in funds and in personal interest. Dr. GRINNELL was chosen director at the beginning and continued in this post with attendant professorial duties until his death. For years he was active in the Cooper Ornithological Club and from 1906 was editor of its journal, *The Condor*. As his field for research GRINNELL chose western North America, from Alaska to Baja California, and to taxonomic and ecological studies of the vertebrates of this region he devoted his active life. While best known for his work in birds, partly perhaps because of his editorship of *The Condor*, he was an authority as well on amphibians, reptiles, and mammals of this vast region. The museum established under his charge has grown until it is today the most important research center in vertebrate zoology in the West, and for many years it has been a place for training graduate students in this subject. GRINNELL himself became the outstanding figure in the Western United States in this field, with international reputation. His published works number about 550 separate titles.

JOSEPH GRINNELL was a scholarly man of quiet tastes and sensitive nature, with which he combined firmness of mind and constant industry in the field of his interests. He cared little for honors demanding public appearance and avoided them under ordinary circumstances. He was exacting and meticulous of detail in his work, and his influence has been potent in the development of his chosen field, both through his own considerable contributions and through his training of others.

WENDELL CLAY MANSFIELD, geologist of the Geological Survey, died at his home in Washington, July 31, 1939. He was born at Charlotte Center, N. Y., June 9, 1874. He received the degrees of Bachelor of Science from Syracuse University in 1908, Master of Science from George Washington University in 1913, and Doctor of Philosophy from the same institution in 1927. He came to Washington in 1910 as a preparator of fossils in the Geological Survey, by which organization he was employed continuously until his death. Doctor MANSFIELD, whose chief field of work was in paleontology, was an authority on the late Tertiary Mollusca of the Southeastern States, particularly of Virginia, the Carolinas, and Florida. He contributed many articles about fossils to this and other journals, and was the author of two professional papers of the Federal Geological Survey and of four bulletins of the Florida Geological Survey. Doctor MANSFIELD was a member of the Academy, the Paleontological Society, the Geological Society of America, and of the Geological, Biological, and Paleontological Societies of Washington.

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JOURNAL
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VOL. 29 NOVEMBER 15, 1939 No. 11

PALEONTOLOGY.—*Two new genera of Carboniferous inadunate crinoids.*[1] EDWIN KIRK, U. S. Geological Survey.

In a former communication to this Journal (Kirk, 1938) several crinoid genera were discussed. These genera centered about *Zeacrinus*, either through genetic affinity or because of assignment of some of their species to that genus by authors. Two new genera, closely related to some of the crinoids dealt with, were omitted owing to nomenclatorial uncertainties. The location and examination of the type specimen of an early and obscure species resolved these difficulties.

In the meantime, a new genus, *Xystocrinus*, has been made by Moore and Plummer. The type species chosen, *Cyathocrinus depressus* Troost, is a typical *Zeacrinus*. Following a long series of errors by authors, Moore and Plummer seem to have had an erroneous idea of the species they chose as type, confusing it at least in part with *Tholocrinus spinosus* (Wood).

The name *Zeacrinus depressus* (Troost) has had a curious history. The type specimen of *Zeacrinus depressus* during Wachsmuth's lifetime was in Hall's Museum at Albany and inaccessible. The only means of identification were the description and excellent line drawings in the Iowa report. Someone, perhaps Wachsmuth himself, decided that certain crinoids from Sloans Valley, Ky., were *Zeacrinus depressus* and referred them to *Hydreionocrinus*. Thus, when Wetherby (1881, p. 325 (2), pl. 9, figs. 1–4, 6) figured the species he called it *H. depressus* under protest, citing Wachsmuth as authority. In the meantime the large series of similar specimens in the Wachsmuth and Springer collection carried the *depressus* label in Wachsmuth's writing, which has remained to this day. Springer (1926, pp. 88, 90, pl. 26, figs. 1–12) briefly described and very fully illustrated this species as *H. depressus*. This work was done away from the collection and with limited access to the literature. Springer had the type specimen of *Zeacrinus depressus* in the same drawer and must have known that the two forms were neither conspecific nor congeneric. It was a most

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[1] Published by permission of the Director of the U. S. Geological Survey. Received June 2, 1939.

unfortunate mistake. Moore and Plummer (1938, p. 271) proposed a new genus *Xystocrinus,* with *Zeacrinus depressus* (Troost) ("Hall") as genotype. As illustrations of the species they gave pen and ink drawings of two of Springer's figures. The type of *Zeacrinus depressus* was examined by both Moore and Plummer, and it is strange they followed the *lapsus* of Springer.

Thirty years ago Wood (1909, pp. 92, 93, pl. 11, figs. 6–8) gave excellent illustrations and description of the type specimen of *Zeacrinus depressus,* referring it to *Hydreionocrinus.* For Wetherby's species referred to *H. depressus* by Wachsmuth, the history of which has been outlined above, Wood gave the new name *H. spinosus.*

There has appeared recently a much-needed revision of the genus *Zeacrinus* by Sutton and Hagan (1939). A few species referred by them to *Zeacrinus* will have to come out. In particular, the species referred by me to my genus *Eratocrinus,* to which they take exception (p. 87), are certainly not referable to *Zeacrinus.* They do, however, agree very well with *E. elegans* (Hall). It should be noted that two of the "species" listed by Sutton and Hagan, *E. ramosus* (Hall) and *E. troostanus* (Meek and Worthen), are based on immature individuals and might possibly fall into synonymy.

The ascription by Sutton and Hagan and most authors of the genotype of *Zeacrinus, Zeacrinus magnoliaeformis,* to Owen and Norwood 1847 (not 1846 as cited) is incorrect. In this paper Owen and Norwood figured a specimen of *Zeacrinus magnoliaeformis* but in the text (1847, p. 5) merely called it "the beautiful *Encrinite,* fig. 13." The correct citation is that given by me (1938, p. 160). The authority for the genus and species as of Troost can not be got around. The footnotes of Hall (1858, p. 544) seem to have escaped authors generally and validate Troost's names under any prevailing code.

The species here referred to the two new genera proposed are those in regard to which I feel reasonably certain, either from examination of the types or well-authenticated specimens. *Dasiocrinus spinosus* (Owen and Shumard) is of special interest. The original figure was very poor, and the species was cited by Wachsmuth and Springer as "undeterminable." The type specimen has been found at the Walker Museum of the University of Chicago and proves to be a splendidly preserved crinoid.

Tholocrinus, n. gen.

Genotype.—Hydreionocrinus spinosus Wood.

Generic diagnosis.—

Crown.	Subcylindrical, short.
Dorsal cup.	Depressed, bowl-shaped, with invaginated base.

IBB. Small, within basal pit, and concealed by column.

BB. Of approximately equal width and height, except post B, which is proportionally higher. Proximal portions of BB take part in basal pit.

RR. Large. Articulating suture extending full width of R, slightly curved, not gaping.

IBr. One in all rays, except the anterior, which is variable. Here there may be one, or a IBr_1, separated from the IAx by a set of biserial or interlocking Br. In such case the structure is essentially that of the IIBr series and is probably homologous, the structure of the anterior ray representing a suppression of one-half the division usually taking place on the IBr_1. The IBr tend to be nodose or spinose.

Arms. The arms are short, stout, and endotomous. The axillaries are relatively large and tend to be nodose. Following each Ax the first brachial is relatively large. Between it and the succeeding Ax the brachials interlock or have a biserial arrangement. The Br of the admedian rami are biserial or nearly so.

Post IR. Three anal plates in cup. RA large, not penetrating deeply between post B and R post B, meeting R post B on narrow face and post B on a much longer one. X meets post B on a wide, horizontal face and rises above the level of the RR. RT is large and extends well above the level of the RR.

Ventral sac. The ventral sac is proportionally very large. Distad it contracts somewhat to about one-half its height, then expands, giving the sac an elongate hourglass shape. The opening lies about one-half the height of the sac. The sac is capped by a low-arched structure, consisting either of spinose plates alone or spinose marginal plates separated at the margin by smaller nonspinose plates and by a central group of smaller plates.

Characteristic species of the genus.—

Tholocrinus armiger (Meek and Worthen), n. comb.

Poteriocrinites (*Zeacrinus?*) *armiger* Meek and Worthen, p. 27, 1870. "Chester, Pope County, Illinois."—Meek and Worthen, p. 547, pl. 21, figs. 3a, b, 1873.

Hydreionocrinus armiger Wachsmuth and Springer, p. 131 (356), 1880.

Tholocrinus spinosus (Wood), n. comb.

Hydreionocrinus spinosus Wood, in Troost, p. 93, 1909.

In error

Hydreionocrinus depressus (Troost) Wetherby ("Wachsmuth non Wetherby"), p. 326 (2), pl. 9, figs. 1–4, 6, 1881.—Wachsmuth and Springer, p. 245 (169), 1886.—Springer, pp. 89, 90, pl. 26, figs. 1–12, 1926.

Xystocrinus depressus Moore and Plummer (part), p. 269, fig. 21, 1938.

Tholocrinus wetherbyi (Wachsmuth and Springer), n. comb.

Hydreionocrinus wetherbyi Wachsmuth and Springer, p. 245 (169), 1886.

In error

Hydreionocrinus armiger (Meek and Worthen) Wetherby ("Wachsmuth non Wetherby"), p. 328 (5), pl. 9, figs. 7–11, 1881.

Geological and geographic distribution.—The genus is widely distributed in Mississippi Valley and Kentucky, where beds of upper Chester are found.

Relationships.—Tholocrinus probably has its nearest relationships with *Linocrinus.* It differs chiefly from *Linocrinus* in the flattened, spinose mushroom-shaped distal portion of the ventral sac, the smoothness of plates, the more advanced stage of evolution of the anal plates, and in having biserial or nearly biserial arms. From *Hydreionocrinus* it chiefly differs in the smoothly rounded cup with invaginated base and in its endotomous arm structure as against what may be called the ectotomous arms of *Hydreionocrinus.*

Dasciocrinus, n. gen.

Genotype.—Cyathocrinus florealis Yandell and Shumard.

Generic diagnosis.—

Crown. Subcylindrical, high.

Dorsal cup. Depressed-turbinate, with invaginated base.

IBB. Small, concealed by column within small basal pit.

BB. Relatively small, the proximal portions taking part in the basal pit.

RR. Large. Articulating suture extends full width of R; linear, gaping.

IBr. One in all rays, tending to be nodose or spinose.

Arms. Long, slender, endotomous, with few divisions. The first division above the main dichotom is high above the IAx, giving a large number of IIBr. In the ant R there tend to be fewer divisions, which are more nearly isotomous. All axillaries tend to be nodose. Br cuneate.

Post IR. Three anal plates in cup. RA large, elongate, penetrating deeply between and resting upon post and r post BB. X relatively small, narrow, meeting post B on a narrow face or separated from it. RT small, meeting RA on a very narrow face.

Ventral sac. The ventral sac is as long as the arms or extends somewhat beyond them. Spinose processes commonly occur on a few of the distal plates of the sac, three or four being the usual number. The anal opening is lateral in position and lies near the distal end of the sac.

Characteristic species of the genus.—

Dasciocrinus florealis (Yandell and Shumard), n. comb.

Cyathocrinus florialis Yandell and Shumard, p. 24, pl. fig. 1, 1847. "Grayson Springs, Kentucky." (Upper Chester, Glen Dean.)

Poteriocrinus florealis Shumard, p. 217, 1855.

Zeacrinus florealis Shumard, p. 399, 1866.—Wachsmuth and Springer, p. 128 (353), 1880.

Pachylocrinus florealis Springer, p. 72, pl. 16, figs. 8, 9, 1926.

Dasciocrinus spinifer (Wetherby), n. comb.

Scaphiocrinus spinifer Wetherby, p. 157 (14), pl. 5, fig. 5, 1880. "Pulaski County, Kentucky, Kaskaskia (Chester) Group." (Glen Dean.).—Wachsmuth and Springer, p. 236 (160), 1886.

Dasciocrinus spinosus (Owen and Shumard), n. comb.

Poteriocrinus spinosus Owen and Shumard, p. 91, pl. 11, fig. 4, 1852.—Owen and Shumard, p. 596, pl. 5b, fig. 4, 1852a. "Archimedal layers of the carboniferous limestone of Kaskaskia, Illinois." Associated with "*Pentremites florealis, P. pyriformis,* . . . and *Poteriocrinus* (*Zeacrinus*) *magnoliaformis* Troost."

Zeacrinus spinosus Shumard, p. 399, 1866.

Geologic and geographic distribution.—The genus is widely distributed in the Mississippi Valley and in Kentucky in beds of Chester age. There is an undescribed species in the Ste. Genevieve near Huntsville, Ala.

Relationships.—*Dasciocrinus* is related to *Tholocrinus*, from which it differs chiefly in its long, slender crown and arms; lack of a pronounced terminal mushroom expansion of the ventral sac; and the depressed turbinate cup as compared with the smoothly rounded cup of *Tholocrinus.*

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BOTANY.—*Arizona plants: New species, varieties, and combinations.*[1]

THOMAS H. KEARNEY and ROBERT H. PEEBLES, U. S. Bureau of Plant Industry.

The writers have in preparation an account of the flowering plants and ferns of the State of Arizona, to which specialists in some of the more difficult families and genera are contributing treatments of the groups with which they are familiar. The object of the present paper is to publish in advance such new species, varieties, and combinations as it has seemed advisable to recognize. Several of our collaborators have contributed descriptions of new forms, or new names and combinations, but unless it is otherwise stated, the present writers are responsible for the novelties enumerated in this paper.

Agave parryi Engelm. var. **couesii** (Engelm.), comb. nov.

Agave couesii Engelm. in Trelease, Ann. Rep. Missouri Bot. Garden **22:** 94. 1911.

Similar to *A. parryi* except for the less closely imbricate rosette, the narrower, more gradually pointed leaves, and usually smaller flowers.

Agave schottii Engelm. var. **treleasei** (Toumey), comb. nov.

Agave treleasei Toumey, Ann. Rep. Missouri Bot. Gard. **12:** 75. 1901.

A rare form, distinguished from *A. schottii* by the dark-green, exceptionally wide, and nearly flat leaves.

Sisyrinchium demissum Greene var. **amethystinum** (Bicknell), comb. nov.

Sisyrinchium amethystinum Bicknell, Bull. Torrey Club **28:** 581. 1901.

Apparently differs from typical *S. demissum* only in size of plant, width of leaves, and size of flowers; and the intergradation seems to be complete, in Arizona.

Sisyrinchium longipes (Bicknell), comb. nov.

Hydastylus longipes Bicknell, Bull. Torrey Club **27:** 382. 1900.

In the writers' opinion, Salisbury's genus *Hydastylus* is entitled to only subgeneric rank.

Phoradendron bolleanum (Seem.) Eichler var. **capitellatum** (Torr.), comb. nov.

Phoradendron capitellatum Torrey, in Trelease Monogr. Phoradendron 25, pl. 17. 1916.

The more copious pubescence and the greater reduction of the first (or only) internode of the fruiting spike seem to be the only characters by which this form can be distinguished from typical *P. bolleanum.*

Eriogonum mearnsii Parry var. **pulchrum** (Eastwood), comb. nov.

Eriogonum pulchrum Eastwood, Proc. California Acad. Sci., ser. 4, **20:** 139. 1931.

The variety differs from typical *E. mearnsii* only in the persistence of loosely lanate pubescence on the upper leaf-surface.

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[1] Received June 10, 1939.

Eurotia lanata (Pursh) Moq. var. **subspinosa** (Rydb.), comb. nov.

Eurotia subspinosa Rydb., Bull. Torrey Club **39**: 312. 1912.

This form differs from typical *E. lanata* in having more pronouncedly woody stems, more spreading branches, and hairs with few or no greatly elongate rays, but these characters are not closely correlated and many of the Arizona specimens are intermediate.

Mirabilis longiflora L. var. **wrightiana** (A. Gray), comb. nov.

Mirabilis wrightiana A. Gray, in Britton & Kearney, Trans. New York Acad. **14**: 28. 1894.

Typically, this form is distinguished by the merely puberulent, scarcely viscid herbage and in having all of the leaf-blades distinctly petioled, but these characters are not always associated and there is complete intergradation in Arizona material.

Oxybaphus linearis (Pursh) Robinson var. **decipiens** (Standley), comb. nov.

Allionia decipiens Standley, North Amer. Flora **21**: 223. 1918.

Var. *decipiens* intergrades freely with typical *A. linearis* but is more or less distinguishable by the more distinctly petioled leaves, broader leaf-blades, and less glaucous stems.

Boerhaavia erecta L. var. **intermedia** (Jones), comb. nov.

Boerhaavia intermedia Jones, Contr. West. Bot. **10**: 41. 1902.

The variety has somewhat smaller fruits and usually more compact and more umbelliform inflorescences than typical *B. erecta,* but there is too much intergradation to justify maintenance of *B. intermedia* as a species.

Abronia angustifolia Greene var. **arizonica** (Standley), comb. nov.

Abronia arizonica Standley, Contr. U. S. Nat. Herb. **12**: 319. 1909.

Differs from typical *A. angustifolia* of New Mexico in the broader leaf-blades and usually more copious pubescence. Specimens without fruit are sometimes difficult to distinguish from *A. villosa* S. Wats.

Cerastium nutans Raf. var. **obtectum,** nom. nov.

Cerastium sericeum S. Wats., Proc. Amer. Acad. **20**: 354. 1885. (Non Pourr., 1788.)

In its extremely sericeous aspect, this form appears distinct from *C. nutans,* but the intergradation in pubescence is complete in Arizona specimens. The two forms are not constantly distinguishable by the seed-characters mentioned by Robinson (in Gray, Syn. Flora N. Amer. **1**: Pt. 1, 230. 1897).

Arenaria saxosa A. Gray var. **mearnsii** (Woot. and Standl.), comb. nov.

Arenaria mearnsii Woot. and Standl., Contr. U. S. Nat. Herb. **16**: 121. 1913.

Var. *mearnsii* is characterized normally by a longer-stemmed and more open plant with longer, narrower leaf-blades than in typical *A. saxosa,* but specimens of intermediate character are of frequent occurrence.

Arenaria eastwoodiae Rydb. var. **adenophora,** var. nov.

A forma typica *A. eastwoodiae* caulibus et sepalis plus minusve glanduloso-puberulentibus distinguitur.

Type: *Peebles & Fulton* 11856, Tuba, Coconino County, Ariz., altitude 5,000 feet (U. S. National Herbarium No. 1634508). This form grows in sandy soil in northeastern Arizona, where it is more common than typical *A. eastwoodiae.*

The presence of glandular puberulence on the stems, especially in the inflorescence, and on the sepals, at least toward base, seems to be the only character differentiating this variety from the typical form of the species.

Delphinium andesicola Ewan, sp. nov.[2]

Herba perennis caulibus strictis robustis, 1–2 m altis, e radice elongati lignosa, simplicibus vel ad basim paucis, caesiis, puberulentis; foliis imprimis caulibus, tri- vel quinquepartibus segmentis amplis, 15–20 cm latis, cuneato-rhomboidis vel -obovatis dentatis longioribus deinde subglabris, mediis petiolis 6–9 cm longis; racemis elongatis atque remotifloribus, 25–35 cm longis; floribus numerosis, pedicellis puberulentis ascendentibus vel divaricatis 2–3 cm longis, sepalis atro-caeruleis atque ovalibus subacutis, 9–12 mm longis, extus cinereo-puberulentis, petalis superioribus azureis vel fere pallidis, inferioribus oblongo-ovatis, emarginatis, subniger, albo-villosis; folliculis oblongibus, 10–14 mm longis, cuspide setoidiis, seminibus 2.5–3 mm longis angulatis angustis alatis.

Type: *J. C. Blumer* 136, Sept. 13, 1906, Barfoot Park, Chiricahua Mountains, Cochise County, Ariz. (Herb. Univ. Ariz.). One sheet in flower, another in ripe fruit, both bearing same data.

A medium to tall stout erect perennial, 1–2 m high, from a stout woody-fibrous deep-seated rootstock; stems simple or few from the rootcrown, leafy to the racemes, purplish, with a uniform fine puberulence; leaves predominantly cauline, the basal similar, withering at flowering time, appearing glabrous but thinly microscopically puberulent, the principal cauline leaves of 3 or 5 cuneate-rhomboid or -obovate divisions, these again pinnatifid distally into narrowly oblong few-toothed long pinnae, the teeth acute, the proximal half of the division-blade entire and gradually narrowed below, the segments 10-15 mm wide at base of the lobes, the midcauline petioles 6–9 cm long; racemes elongate, open, 25–35 cm long; flowers numerous, on ascending or spreading puberulent pedicels 2–3 cm long, their sepals dull ashy- or dark-blue, ovate, barely acute, 9–12 mm long, cinereous-puberulent thinly so at anthesis, the upper petals pale blue, the lower petals oblong-ovate, notched (sinus 1 mm deep), blue-purple, moderately white-villous; follicles oblong, obscurely venulose, 10–14 mm long, with short thin pricklelike cusp; seeds 2.5–3 mm long, the angles narrowly winged.

Grows in swales on slopes covered with open forest of *Pinus ponderosa,* in the Chiricahua, Huachuca, and Santa Rita Mountains, at elevations of 5,000 to 8,500 feet. Other collections examined: Topotype, *Blumer* 1373; Huachuca Mountains: Garden Canyon, *Harrison and Kearney* 5770; Ramsey Canyon, *Jones* 24847 (sheets vary widely among herbaria). Santa Rita Mountains: *Wooton,* Sept. 30, 1913; Madera Canyon, *Peebles and Harrison* 2958; Stone Cabin Canyon, *Thornber,* July 15, 1903.

Delphinium sierra-blancae Wooton subsp. **amplum** Ewan, subsp. nov.[3]

A *D. sierra-blancae* f. *typico* caulibus subglabris stramineis, foliis tripartibus segmentis ampliore atque latiore cuneato-obovatis dentatis brevioribus ad basim integris differt.

Type: *Kearney and Peebles* 12274, White Mountains, 6 miles south of Han-

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[2] Contributed by Joseph Ewan, University of Colorado.

[3] Contributed by Joseph Ewan.

nigan Meadow, 9,500 feet, Greenlee County, Ariz., August 11, 1935 (U. S. National Herbarium No. 1651077).

Stems subglabrous at least below, usually light colored; leaves darker green, more ample, 3-parted into broader segments, these cuneate-obovate, again pinnatifid distally into short few-toothed or entire pinnae, the teeth abruptly or barely acute, the proximal portion nearly oblong, entire and less abruptly narrowed, the segments 18–27 mm wide at base of the lobes.

Wet creek bottoms of mountains about the headwaters of the Salt River and along the upper Gila River, from Mount Graham north to White Mountains, at elevations of 6,500 to 9,500 feet. Other collections examined: Mount Graham, 8,000 ft., *Kearney and Peebles* 9810 ; same loc., 9,000 ft., *Kearney and Peebles* 9868; Thompson Ranch, Black River, White Mountains, *Gooding* 564.

Delphinium andesicola, most often identified as "*D. scopulorum*" or "*D. scopulorum stachydeum,*" is apparently more closely related to the poorly known *D. tenuisectum* Greene of the Sierra Madre Occidentál of Mexico than to *D. scopulorum* Gray. *Delphinium andesicola* has a natural floristic range in southeastern Arizona. *Delphinium scopulorum* is in reality a fairly local species though currently misinterpreted as a widespread paludose larkspur of virtually the whole of western North America. So far as known it is confined to New Mexico in its typical form.

Delphinium sierra-blancae Wooton is based on E. O. Wooton's collection from Gilmore Ranch, White Mountains, Lincoln County, N. Mex., at 7,500 feet, July 27, 1901; the type (New Mexico Coll. Agr. and Mech. Arts, State College, N. Mex.) has been studied. The subspecies *amplum* occupies the White Mountains of Arizona where it replaces the species. From *D. andesicola* of more southerly distribution, *D. sierra-blancae* may be recognized by its acute unhooded sepals.

Aconitum columbianum Nutt. var. **glaberrimum** (Rydb.), comb. nov.

Aconitum glaberrimum Rydb., Bull. Torrey Club **29**: 151. 1902.

The glabrous stems and glabrous or nearly glabrous leaves are apparently the only distinguishing characters of this form.

Berberis harrisoniana, sp. nov.

Frutex 0.5–0.7 m altus; folia palmate-trifoliolata, foliolis sessilibus rhomboideo- vel triangulari-cuneatis coriaceis laete-viridibus non glaucis subtus vix pallidioribus dentibus spinosis magnis triangularibus 1 vel 2 utroque latere, foliolo terminali 3–5 cm longo 2.5–3.5 cm lato petiolum aequante vel subaequante; inflorescentia brevis corymbiformi-racemosa; sepala interiora petalis majora plus minusve 6 mm longa; filamenta apicem versus bidentata dentibus divergentibus calcaribus similibus; baccae globosae vel subovoideae nigro-coeruleae subglaucae 5–6 mm diametro.

Type: *Peebles and Loomis* 6768, in a canyon of the Kofa Mountains, Yuma County, Ariz., March 31, 1930, in fruit (U. S. National Herbarium No. 1468221). Known only from the type locality, where it was collected in flower on February 26, 1932, by R. E. Beckett (No. 9079).

The outer bark is pale brown on the branchlets, gray on the older stems the inner bark bright yellow. The veins are inconspicuous in fresh leaves. This plant resembles *B. trifoliolata* Moric. in the palmately trifoliolate leaves with petiole not articulated below the junction of the leaflets, but differs in the toothed filaments and the blue-black color of the berries.

The writers take pleasure in dedicating this species to their colleague, George J. Harrison, whose activity in collecting plants during his residence in Arizona contributed materially to our knowledge of the flora.

Streptanthus arizonicus S. Wats. var. **luteus,** var. nov.

A forma typica *S. arizonici* calyce luteo, stylo longiore, siliquis ad apicem magis attenuatis et rostratis distinguitur.

Type: *Kearney* 10813, Canyon Diablo, Ajo Mountains, Pima County, Ariz. (U. S. National Herbarium No. 1634074). Known only from the type collection.

The bright yellow color of the calyx soon fades, in dried specimens, to the normal ochroleucous hue of *S. arizonicus.* The style is 1 to 2 mm. long, whereas in most specimens of *S. arizonicus* it is less than 1 mm long.

Descurainia obtusa (Greene) Schulz var. **adenophora** (Woot. and Standl.), comb. nov.

Sophia adenophora Woot. and Standl., Contr. U. S. Nat. Herb. **16**: 127. 1913.
Descurainia obtusa Schulz, Pflanzenr. IV, **105**: 321. 1924.

This form apparently differs from typical *D. obtusa* only in the presence of glandular hairs in the inflorescence, and in having the pods often glabrescent.

Arabis tricornuta Rollins, sp. nov.[4]

Herba perennis; caulibus erectis singulis superne ramosis, 3–6 dm altis, inferne sparse pubescentibus superne glabris; foliis radicalibus ignotis; foliis caulinis infimis petiolatis oblanceolatis pubescentibus 3–5 cm longis, ca. 1 cm latis, pilis ramosis, supremis linearibus vel lanceolatis glabris; inflorescentiis racemosis laxis gracilibus; sepalis glabris oblongis 3–4 mm longis, 2–3 mm latis; petalis albis lingulatis vel spathulatis 4–5 mm longis, ca. 1.5 mm latis; pedicellis gracilibus recurvatis glabris 1–1.5 cm longis; siliquis angustis plano-compressis patentibus vel pendulis glabris inferne 1-nervatis, 3–7 cm longis, ca. 2 mm latis; seminibus uniseriatis orbicularibus alatis ca. 1.5 mm latis.

Perennial; stems single, branched above, pubescent below with simple or branched trichomes, glabrous above, 3–6 dm high; basal leaves caducous, unknown; lower cauline leaves petiolate, oblanceolate, pubescent with harsh 2- or usually 3-pronged trichomes, 3–5 cm long, ca. 1 cm wide; upper cauline leaves linear to narrowly lanceolate, glabrous; inflorescence racemose, lax, slender, greatly elongated; sepals glabrous, oblong, 3–4 mm long, 2–3 mm wide, unequal, not saccate, inner pair tapering at base; petals white, lingulate to nearly spatulate, thickened toward base with edges rolled outward, erose to entire along petal margin, not differentiated into blade and claw, 4–5 mm long, ca. 1.5 mm wide; stamens slightly shorter than petals, filament of short stamen curved, filament of long stamen straight; nectar glands surrounding short stamens, only subtending long stamens; pedicels slender, gently curved downward, glabrous, 1–1.5 cm long; siliques linear, flattened parallel to septum, glabrous, 1-nerved to middle or above, spreading at right angles to widely pendulous, 3–7 cm long, ca. 2 mm wide; style ca. 1 mm long; stigma entire; seeds flat, orbicular, conspicuously winged all around, ca. 1.5 mm broad, uniseriate; cotyledons obliquely accumbent.

Arabis tricornuta is particularly interesting because at anthesis it is very difficult to distinguish from *Thelypodium micranthum.* In habit, inflorescence, flower, and type of pubescence they are almost identical. One minor feature

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[4] Contributed by Reed C. Rollins, Gray Herbarium, Harvard University.

of flower similarity is particularly striking. In both species the short stamen arises at right angles to the ovary and then curves upward. This particular characteristic has not been observed in other species of *Arabis*, but it is not of major importance as a diagnostic character, since there is considerable variation in stamen insertion throughout the genus. The definitely winged seeds, accumbent coryledons, and markedly flattened siliques of *A. tricornuta* leave little doubt about its being properly placed in *Arabis*, in spite of the striking similarity it shows at the flowering stage to another species of a different genus.

Arabis tricornuta is not closely related to any North American species of *Arabis*, but the flower, inflorescence, and upper parts of the plant are similar to *A. laevigata*. The new species is somewhat like *A. repanda*, particularly as regards the petiolate cauline leaves, but the similarity is only superficial. *A. tricornuta* is apparently restricted to the mountains of southern Arizona, where it has been collected at elevations between 7,000 and 9,000 feet.

ARIZONA: Eastview, Rincon Mountains, Oct. 13, 1909, *J. C. Blumer* 3478 (Gray Herb., type); Rincon Mountains, 1891, *G. C. Neally* 120 in part (U. S. Nat. Herb.); Santa Rita Mountains, Aug. 23, 1936, *Robert Darrow* and *J. Arnold* (Gray Herb.). There is a Blumer collection in the U. S. National Herbarium labeled *Castilleja minor*, which is partly *Arabis tricornuta* and partly *Thelypodium micranthum*. This specimen supposedly came from the Chiricahua Mountains, but the label is obviously a transposed one; hence the data cannot be trusted.

Sedum wootoni Britton var. **griffithsii** (Rose), comb. nov.

Sedum griffithsii Rose, North Amer. Flora **22**: 71. 1905.

There seems to be no character that distinguishes var. *griffithsii* from typical *S. wootoni* except the more distinctly papillate basal leaves.

Echeveria bartramii (Rose), comb. nov.

Graptopetalum bartramii Rose, Addisonia **11**: 1, pl. 353. 1926.

The characters on which were based the genera *Graptopetalum* Rose and *Dudleya* Britton and Rose are, in the opinion of the writers, of subgeneric rather than generic value.

Echeveria arizonica (Rose), comb. nov.

Dudleya arizonica Rose, Addisonia **8**: 35, pl. 274. 1923.

This species evidently is related to *E. pulverulenta* Nutt. of southern California but is perhaps sufficiently distinguished by the smaller size of the plant, less pulverulent herbage and smaller flowers.

Echeveria collomae (Rose), comb. nov.

Dudleya collomae Rose, in Morton, Desert [Plant Life] **6**: 68. 1934.

Closely related to several forms of southern California that have been described as species, *E. collomae* is presumably the Arizona plant referred to *Dudleya parishii* Rose in North American Flora (**22**: 41. 1905). Specimens of this species collected in Arizona by M. E. Jones were identified by him as *Cotyledon saxosum* M. E. Jones (*Dudleya saxosa* Britton and Rose, *Echeveria saxosa* Nels. and Macbr.), the type of which, a smaller plant, was collected in the Panamint Mountains, Calif.

Saxifraga rhomboidea Greene var. **franciscana** (Small), comb. nov.

Micranthes franciscana Small, North Amer. Flora **22**: 144. 1905.

Saxifraga franciscana Fedde, in Just, Bot. Jahresb. **33**: pt. 1, 613. 1906.

S. rhomboidea var. *typica* f. *franciscana* Engler and Irmscher, Pflanzenr. IV. 117. 28. 1916.

The filaments of var. *franciscana* are described as clavate by Small but do not appear to be so in specimens from the type locality.

Heuchera versicolor Greene var. **leptomeria** (Greene), comb. nov.

Heuchera leptomeria Greene, Leaflets **1**: 112. 1905.

Apparently this form differs from typical *H. versicolor* only in the narrower hypanthium and lower part of the ovary and there is too much intergradation to warrant maintenance of *H. leptomeria* as a species.

Philadelphus microphyllus A. Gray var. **argenteus** (Rydb.), comb. nov.

Philadelphus argenteus Rydb., North Amer. Flora **22**: 171. 1905.

The variety differs from typical *P. microphyllus* only in the copious to dense pubescence of the hypanthium and upper surface of the leaves, these being glabrous or sparsely pubescent in the typical form.

Fendlerella utahensis (S. Wats.) Heller var. **cymosa** (Greene), comb. nov.

Fendlerella cymosa Greene, in Woot. and Standl., Contr. U. S. Nat. Herb. **16**: 129. 1913.

The leaves are normally narrower and more acute in var. *cymosa* than in typical *F. utahensis* and the two forms are widely separated geographically, typical *utahensis* occurring in southern Utah, southern Nevada and northern Arizona, whereas var. *cymosa* is found in the mountains of southern New Mexico, southern Arizona, and northern Mexico.

Fendlera rupicola A. Gray var. **tomentella** (Thornber), comb. nov.

Fendlera tomentella Thornber, in Woot. and Standl., Contr. U. S. Nat. Herb. **16**: 129. 1913.

In this variety the leaf-blades are rather densely white-pubescent beneath and are usually narrower and more strongly revolute than in typical *F. rupicola.*

Crossosoma bigelovii S. Wats. var. **glaucum** (Small), comb. nov.

Crossosoma glaucum Small, North Amer. Flora **22**: 232. 1908.

Although intergradation with the typical form is complete, var. *glaucum* normally has the follicles broader (ovoid or obovoid) and more glaucous than in typical *C. bigelovii.*

Rubus strigosus Michx. var. **arizonicus** (Greene), comb. nov.

Batidaea arizonica Greene, Leaflets **1**: 243. 1906.
Rubus arizonicus Rydb., North Amer. Flora **22**: 446. 1913.

The Arizona form apparently differs from eastern specimens of *R. strigosus* merely in having the leaves of the shoots 5- to 9-foliolate (instead of 3- to 5-foliolate) and those of the flowering branches mostly 5-foliolate but occasionally 3-foliolate.

Potentilla crinita A. Gray var. **lemmoni** (S. Wats.) comb. nov.

Ivesia lemmoni S. Wats., Proc. Amer. Acad. **20**: 365. 1885.
Potentilla lemmoni Greene, Pittonia **1**: 104. 1885.

The variety differs from typical *P. crinita* in its stiffer, more erect stems, leaflets toothed only at or very near the apex, and petals usually not surpassing the sepals.

Potentilla subviscosa Greene var. **ramulosa** (Rydb.), comb. nov.

Potentilla ramulosa Rydb., Bull. Torrey Club **23**: 430. 1896.

There is little to distinguish this variety from typical *P. subviscosa* except that the leaflets are usually only coarsely toothed, whereas in the typical form of the species they are cleft more than halfway to the midvein. The basal leaves in var. *ramulosa* are occasionally subpinnate rather than strictly digitate.

Potentilla multifoliolata (Torr.), comb. nov.

Horkelia? multifoliolata Torr., Sitgreaves Rep. Zuni & Colo. 159. 1853.
Comarella multifoliolata Rydb., Mem. Bot. Columbia Univ. **2**: 156. 1898.
Ivesia multifoliolata Keck, Lloydia **1**: 125. 1938.

Potentilla thurberi A. Gray var. **atrorubens** (Rydb.), comb. nov.

Potentilla atrorubens Rydb., Bull. Torrey Club **24**: 11. 1897.

The variety seems to be distinguishable only in having the lower surface of the leaflets rather densely silvery-sericeous whereas in typical *P. thurberi* it is only sparsely sericeous, not silvery.

Potentilla thurberi A. Gray var. **sanguinea** (Rydb.), comb. nov.

Potentilla sanguinea Rydb., North Amer. Flora **22**: 324. 1908.

This form differs from typical *P. thurberi* in having the leaves subpinnate with a very short rachis between the pairs of leaflets, instead of strictly digitate or very nearly so.

Geum ciliatum Pursh var. **griseum** (Greene), comb. nov.

Erythrocoma grisea Greene, Leaflets **1**: 178. 1906.
Sieversia grisea Rydb., North Amer. Flora **22**: 409. 1913.

From typical *G. ciliatum* the variety differs in having the bracts less conspicuously surpassing the sepals and the leaflets less deeply dissected.

Geum strictum Ait. var. **decurrens** (Rydb.), comb. nov.

Geum decurrens Rydb., North Amer. Flora **22**: 404. 1913.

This is the common form of the species in the southern Rocky Mountain region, with the upper divisions of the leaves decurrent on the rachis and more or less confluent.

Cercocarpus montanus Raf. var. **flabellifolius** (Rydb.), comb. nov.

Cercocarpus flabellifolius Rydb., North Amer. Flora **22**: 422. 1913.

Differs from typical *C. montanus* in the more appressed pubescence of the leaves and hypanthium-tube.

Rosa arizonica Rydb. var. **granulifera** (Rydb.), comb. nov.

Rosa granulifera Rydb., North Amer. Flora **22**: 517. 1918.

As compared with typical *R. arizonica*, var. *granulifera* has the leaflets more or less double-serrate (the smaller teeth often reduced to glands), the lower surface of the leaflets more copiously granuliferous, and stipitate glands more constantly present on the backs of the sepals.

Prunus emarginata (Dougl.) Walp. var. **crenulata** (Greene), comb. nov.

Cerasus crenulata Greene, Proc. Biol. Soc. Washington **18**: 56. 1905.
Prunus crenulata Tidestrom, Proc. Biol. Soc. Washington **40**: 119. 1927.

Characterized, in comparison with the typical form of the species, by the narrower, elliptic or oblanceolate, more acute leaf-blades.

Acacia hirta Nutt. var. **suffrutescens** (Rose), comb. nov.

Acacia suffrutescens Rose, Contr. U. S. Nat. Herb. **12**: 409. 1909.
Acaciella suffrutescens Britton and Rose, North Amer. Flora **23**: 103. 1928.

The variety is scarcely distinguishable from typical *A. hirta* except that the plant is commonly distinctly suffrutescent. Lateral veins are scarcely perceptible in the leaflets of the type specimen of *A. suffrutescens.*

Acacia hirta Nutt. var. **shrevei** (Britton and Rose), comb. nov.

Acaciella shrevei Britton and Rose, North Amer. Flora **23**: 105. 1928.

As compared with typical *A. hirta* and var. *suffrutescens,* this form has leaflets with distinct lateral veins, some of these often branching from the midrib far above the base of the leaflet. There is complete intergradation among these three forms of *A. hirta.*

Mimosa dysocarpa Benth. var. **wrightii** (A. Gray), comb. nov.

Mimosa wrightii A. Gray, Pl. Wright **2**: 52. 1853.

Typically this variety is characterized by somewhat narrower, unarmed pods (pods usually with a few marginal prickles in *M. wrightii*), glabrous or glabrate upper leaf-surface, and longer inflorescences than in the typical form, but there is much variation in both forms, and the intergradation seems complete.

Mimosa grahami A. Gray var. **lemmonii** (A. Gray), comb. nov.

Mimosa lemmonii A. Gray, Proc. Amer. Acad. **19**: 76. 1883.
Mimosopsis lemmonii Britton and Rose, North Amer. Flora **23**: 176. 1928.

The variety has copiously pubescent young twigs, leaves, flowers, and pods, whereas in typical *M. grahami* these parts are normally glabrous or sparsely pubescent. There appear to be no other distinguishing characters.

Sophora formosa, sp. nov.

Frutex 1–2 m altus; folia sempervirentia pinnata, foliolis 7–13 ellipticis obtusis 15–30 mm longis 10–12 mm latis coriaceis, primo utrinque argenteo-sericeis deinde supra strigosis; inflorescentia dense racemosa plus minusve 4 cm longa; calyx 8–9 mm longus sericeus brevidentatus; corolla purpurea vel violacea plus minusve 16 mm longa, vexilli lamina late-ovala 14–18 mm longa fere tam lata quam longa, alarum lamina paullo breviora, carinae petalorum lamina 10–13 mm longa quam unguibus vix duplo longiora; legumen usque ad 14 cm. longum 11–13 mm latum planum plus minusve torulosum; semina 2–5 rubro-fusca 6–11 mm longa 6–7.5 mm lata.

Type: *Bassett Maguire* 10993, below Frye Mesa, northern foothills of the Pinaleno Mountains, Graham County, Ariz., April 1935 (U. S. National Herbarium No. 1731764).

The bark of the twigs is gray-green, that of the old stems dark gray, rough and furrowed. The mature leaflets are dark green and slightly glossy above, with only the midvein prominent beneath. The pods are acuminate at apex and are sparsely strigose (more densely so at the constrictions). The seeds average 9.2 mm long and 6.5 mm wide. *S. formosa* closely resembles *S. arizonica* S. Wats., but the latter has a larger corolla (about 22 mm long), an oblong-obovate (instead of broadly oval) banner-petal 18 to 20 mm long and only two-thirds as wide as long (four-fifths as wide as long in *S. formosa*), keel-petals with blades 2.5 times as long as their claws (1.5 to 2 times as long in *formosa*); and slightly larger seeds, averaging 9.9 mm long, 7.4 mm wide (averaging 9.2 and 6.5 mm in *formosa*). All the petals are relatively broader, in *S. formosa,* the leaflets of that species are usually longer, broader, and more obtuse, and the pubescence is denser and more persistent on the upper leaf-surface and on the pods.

At a second station for *S. formosa,* also in the northern foothills of the Pinaleno Mountains, about 13 miles southwest of the town of Pima, at about 3,000 feet altitude, C. J. Humphrey collected mature seeds on June 11, 1937. The writers visited the type locality, about 4½ miles south of Thatcher, on April 25, 1939, and found the plant locally abundant on eroded slopes with northern exposure, extending from the lower edge of Frye Mesa, at about 3,700 feet altitude, where it is associated with *Quercus turbinella, Yucca, Dasylirion,* and *Fouquieria,* down to the base of the escarpment at about 3,400 feet, where *Covillea, Prosopis,* and *Fouquieria* are the principal woody species. These, the only known stations of *S. formosa,* are 250 to 300 miles southeast of the only known stations of *S. arizonica,* in Mohave County, along the eastern foothills of the Hualpai Mountains and on Big Sandy Wash, 60 miles south of Kingman. Both species give the impression of being relict forms, suggesting that they may have had a common ancestor of much wider distribution.

Lotus greenei Ottley, nom. nov.[5]

Hosackia mollis Greene, Bull. California Acad. **1**: 185. 1885.
Lotus mollis Greene, Pittonia **2**: 143. 1890. (Non Balf. f. 1882.)

Lotus oroboides (HBK.) Ottley, nom. nov.[5]

Tephrosia oroboides HBK., Nov. Gen. et Sp. **6**: 462. 1823.
Hosackia puberula Benth., Pl. Hartweg. 305. 1849.
Lotus puberulus Greene, Pittonia **2**: 142. 1890.

Psoralea mephitica Wats. var. **retrorsa** (Rydb.), comb. nov.

Pediomelum retrorsum Rydb., North Amer. Flora **24**: 22. 1919.

The variety differs from typical *P. mephitica* in its larger leaflets, longer central peduncle and inflorescence, and larger corolla.

Amorpha fruticosa L. var. **occidentalis** (Abrams), comb. nov.

Amorpha occidentalis Abrams, Bull. New York Bot. Garden **6**: 394. 1910.

This form apparently differs from the variable and widely distributed *A. fruticosa* only in its usually more elongate spikes, these, more frequently than in the typical form, only 1 or 2 on the branchlet.

Dalea leporina (Ait.), comb. nov.

Psoralea leporina Ait., Hort. Kew. **3**: 81. 1789.
Parosela leporina Rydb., North Amer. Flora **24**: 78. 1920.

Dalea nana Torrey var. **carnescens** (Rydb.), comb. nov.

Parosela carnescens Rydb., Fl. Rocky Mts. 483. 1917.

Differs from typical *D. nana* in having the upper surface of the leaflets green and glabrescent rather than sericeous, and in having usually stouter stems.

Dalea polygonoides A. Gray var. **laevituba,** var. nov.

A *D. polygonoides* f. *typica* calycis tubo externe glabro distinguitur.

In typical *D. polygonoides* the whole of the calyx is silky-villous externally.

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[5] Contributed by Alice M. Ottley, Department of Botany, Wellesley College.

Type: *Harrison, Kearney, & Fulton* 8089, Santa Catalina Mountains, Pima County, Ariz., August 23, 1931, growing on rocks at an altitude of 7,500 feet (U. S. National Herbarium No. 1530853). The variety was collected previously in the same locality (*Shreve* 5408) and occurs also in the Chiricahua Mountains, Cochise County, Ariz., at an altitude of 8,200 feet (*Blumer* 1652, 1653) and in southern New Mexico.

Dalea whitingi, sp. nov.

Frutex intricate ramosus interdum 0.8 m altus; rami spinescentes pilis retrorsis canescentes glandulis aurantiacis pustulati denique straminei glabrique; stipulae cartilaginosae subulatae glanduliferae 1 mm longae; folia oblonga imparipinnata 12–24 mm longa antrorse strigosa, stipellis glandulosis, foliolis 11–19 crassis involutis 2–4 mm longis oblongis vel oblanceolatis obtusis vel truncatis subtus pustulatis in petiolulis brevibus contractis; inflorescentia racemosa spinescens 1–3 cm longa, pedunculo 7–20 mm longo, floribus 1–8, bracteis parvis cartilaginosis, pedicellis adscendentibus 1 mm longis; calyx externe villosus, tubo turbinato 2.5–3 mm longo 10-costato inter nervos glandulis 1-5 aurantiacis obsito, lobis rotundis vel obtusissimis fere tam latis quam longis glandulam apicalem munitis, lobo maximo 2 mm longo; petala hypanthio ad basin tubi staminum inserta, laminis longitudine subaequalibus fere 5 mm longis glandulam unicam apicem versus interdum munitis, vexilli lamina suborbiculari emarginata, laminis ceteris oblique-oblongis basi lobatis, vexilli et alarum unguibus 2 mm longis, carinae petalorum unguibus 3 mm longis; stamina monadelphia supra medium connata; ovarium 2-ovulatum villosum lateribus pustulatum 3.5 mm longum stylo villoso 3.5 mm longo attenuatum; fructus ignotus.

Type: *Whiting & Jones* 916/3277, Wupatki National Monument on Little Colorado River, Coconino County, Ariz., August 9, 1938 (U. S. National Herbarium No. 1732120).

Related to *Dalea thompsonae* (Vail) L. O. Williams, from which it is distinguished mainly by the greater number of leaflets (these only 5 to 9 in *thompsonae*), narrower leaflets (these elliptic or slightly obovate in *thompsonae*), and in having the calyx-tube villous externally and with less prominent ribs. Both species have the petals inserted on the hypanthium, appearing in this and other respects to be closely related to the species Rydberg placed in his genus *Psorothamnus*.

Dalea wislizeni A. Gray var. **sanctae-crucis** (Rydb.), comb. nov.

Parosela sanctae-crucis Rydb., North Amer. Flora **24**: 103. 1920.

Herbage glabrous or nearly so, not villous or villous-canescent as in typical *D. wislizeni.*

Robinia neomexicana A. Gray var. **subvelutina** (Rydb.), comb. nov.

Robinia subvelutina Rydb., North Amer. Flora **24**: 227, 1924.

This variety is distinguished from the typical form of *R. neomexicana* by the glandular-hispid pubescence of the pods and from var. *luxurians* Dieck by the rather loose, somewhat spreading pubescence of the herbage and by the usually more copiously glandular-pubescent young stems and petioles.

Astragalus egglestonii (Rydb.), comb. nov.

Tium egglestonii Rydb., North Amer. Flora **24**: 396. 1929.

This species evidently is closely related to *A. rusbyi* Greene, although Rydberg (ibid., p. 380) placed the latter in a different segregate genus, *Atelo-*

phragma. Astragalus egglestonii differs chiefly in its glabrous, shorter-stipitate pods.

Astragalus sonorae A. Gray var. **tenerrimus** (M. E. Jones), comb. nov.

Astragalus humistratus var. *tenerrimus* M. E. Jones, Proc. California Acad. II, **5**: 649. 1894.
Batidophaca tenerrima Rydb., North Amer. Flora **24**: 316. 1929.

This seems to be only a form of *A. sonorae* with smaller leaflets and shorter fewer-flowered racemes.

Hedysarum mackenzii Richards. var. **pabulare** (A. Nelson), comb. nov.

H. pabulare A. Nelson, Proc. Biol. Soc. Washington **15**: 185. 1902.

This form has relatively narrow leaflets and relatively small flowers as compared with specimens of *H. mackenzii* from farther north.

Desmodium metcalfei (Rose and Painter), comb. nov.

Meibomia metcalfei Rose and Painter, Bot. Gaz. **40**: 144. 1905.

Galactia wrightii A. Gray var. **mollissima,** var. nov.

A forma typica *G. wrightii* caulibus et foliis velutino-tomentosis pilis fere omnibus patentibus distinguitur.

In typical *G. wrightii* the pubescence is sericeous and most of the hairs are appressed.

Type: *Peebles, Harrison & Kearney* 4657, near Patagonia, Santa Cruz County, Ariz., August 7, 1927, in flower (U. S. National Herbarium No. 1368950). Also has been collected at Paradise, Cochise County, 5,500 feet (*Blumer* 1799, in fruit); in the Pinaleno Mountains, Graham County, 5,100 feet (*Kearney & Peebles* 14103); and "in Arizona" (*Rothrock* 387).

Phaseolus wrightii A. Gray var. **grayanus** (Woot. and Standl.), comb. nov.

Phaseolus grayanus Woot. & Standl., Contr. U. S. Nat. Herb. **16**: 139. 1913.

The variety intergrades with typical *P. wrightii* but usually has larger leaflets, longer peduncles, and more persistently pubescent pods.

Geranium atropurpureum Heller var. **furcatum** (Hanks), comb. nov.

Geranium furcatum Hanks, North Amer. Flora **25**: 16. 1907.

This differs from the typical form apparently only in the presence of glandular hairs, at least on the pedicels.

Linum aristatum Engelm. var. **australe** (Heller), comb. nov.

Linum australe Heller, Bull. Torrey Club **25**: 627. 1898.

The variety is characterized by usually shorter sepals and petals and by having the inner sepals dentate rather than merely denticulate; also by the commonly more branched stems and serrulate leaves, these being mostly entire in the typical form. There is, however, much intergradation.

Kallstroemia californica (S. Wats.) Vail var. **brachystylis** (Vail), comb. nov.

Kallstroemia brachystylis Vail, Bull. Torrey Club **24**: 206. 1897.

As compared with typical *K. californica*, this form has usually fewer leaflets and shorter, blunter tubercles on the carpels, but there is too much intergradation to warrant specific distinction.

Ptelea angustifolia Benth. var. **cognata** (Greene), comb. nov.

Ptelea cognata Greene, Contr. U. S. Nat. Herb. **10**: 62. 1906.

This form is distinguished by the glabrescent, instead of permanently pubescent, lower leaf-surface.

Acer glabrum Torrey var. **neomexicanum** (Greene), comb. nov.

Acer neomexicanum Greene, Pittonia **5**: 3. 1902.

This form differs from typical *A. glabrum* and resembles *A. glabrum* var. *tripartitum* (Nutt.) Pax in having at least some of the leaves 3-parted instead of merely lobed. From var. *tripartitum* it differs in the more deeply and acutely toothed leaf-margins and in having the terminal division longer-cuneate at base.

Rhamnus betulaefolia Greene var. **obovata,** var. nov.

Laminae foliorum obovatae crassiusculae 5–8 cm longae 4–5.5 cm latae.

Type: *Peebles & Smith* 13930, south end of Navajo Mountain, Coconino County, Ariz., at an altitude of 6,300 feet (U. S. National Herbarium No. 1732315). Occurs also in San Juan County, Utah, in Armstrong and White Canyons, 5,000 to 5,500 feet (*Rydberg & Garrett* 9411) and in Cottonwood Canyon, 4,200–4,500 feet (*Maguire* et al. 5750). A collection in the Charleston Mountains, Nev. (*Clokey* 727) has less pronouncedly obovate blades.

In typical *R. betulaefolia* the leaf-blades are elliptic or oblong, usually narrower, thinner, and with veins slenderer and less prominent beneath than in var. *obovata.* The variety occurs considerably to the north and northwest of the main range of *R. betulaefolia.*

Sphaeralcea spp.

The following combinations, previously published as subspecies, are here renamed as varieties in conformity with the practice of most American botanists. The references in parentheses are to pages in the publication in which the subspecies were published.[6] *S. coulteri* var. *californica* (Rose) Kearney (p. 32); *S. coulteri* var. *margaritae* (Brandegee) Kearney (p. 33); *S. axillaris* var. *rosacea* (Rose) Kearney (p. 36); *S. emoryi* var. *variabilis* (Cockerell) Kearney (p. 39); *S. emoryi* var. *nevadensis* Kearney (p. 40); *S. emoryi* var. *arida* (Rose) Kearney (p. 41); *S. ambigua* var. *rosacea* (Munz and Johnston) Kearney (p. 46); *S. ambigua* var. *monticola* Kearney (p. 47); *S. ambigua* var. *rugosa* Kearney (p. 49); *S. ambigua* var. *versicolor* Kearney (p. 50); *S. rusbyi* var. *gilensis* Kearney (p. 54); *S. rusbyi* var. *eremicola* (Jepson) Kearney (p. 56); *S. incana* var. *cuneata* Kearney (p. 59); *S. fendleri* var. *elongata* Kearney (p. 62); *S. fendleri* var. *albescens* Kearney (p. 62); *S. fendleri* var. *tripartita* (Woot. and Standl.) Kearney (p. 63); *S. fendleri* var. *venusta* Kearney (p. 63); *S. angustifolia* var. *lobata* (Wooton) Kearney (p. 69); *S. subhastata* var. *connata* Kearney (p. 75); *S. subhastata* var. *martii* (Cockerell) Kearney (p. 76); *S. subhastata* var. *latifolia* Kearney (p. 77); *S. subhastata* var. *thyrsoidea* Kearney (p. 77); *S. subhastata* var. *pumila* (Woot. and Standl.) Kearney (p. 78); *S. munroana* var. *subrhomboidea* (Rydberg) Kearney (p. 85); *S. grossulariaefolia* var. *pedata* (Torrey) Kearney (p. 88); *S. digitata* var. *tenuipes* (Woot. and Standl.) Kearney (p. 91); *S. coccinea* var. *dissecta* (Nutt.) Kearney (p. 96); *S. coccinea* var. *elata* (Baker) Kearney (p. 97).

Koeberlinia spinosa Zucc. var. **tenuispina,** var. nov.

Frutex ramulis spinosis elongatis tenuis plerumque 5–9 cm longis ad basin, 1.5–3 mm crassis; cortex coeruleo-viridis; sepala deltoide-ovata 1.5–2 mm

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[6] Kearney, Thomas H. The North American species of *Sphaeralcea,* subgenus *Eusphaeralcea.* Univ. California Publ. Bot. **19**: 1–102. 1935.

longa longiora quam lata distincte denticulata; petala 4.2–6 mm longa; filamenta 2.5–5 mm longa.

Type: *Kearney & Peebles* 10969, Horse Tank, Castle Dome Mountains, Yuma County, Ariz., March 25, 1935 (U. S. National Herbarium No. 1634130). Has been collected in Yuma County, Ariz., near Wenden (*Peebles & Loomis* 6740) and in the Kofa Mountains (*Peebles & Loomis* 6772), and between Mesquite and Altar, Sonora (*F. Long* 27). Flowers in March.

Typical *K. spinosa,* which apparently occurs nowhere west of Tucson, Ariz., is usually lower-growing than var. *tenuispina,* which reaches a height of 3.6 meters. The typical form normally has shorter and stouter spines (3 to 6 cm long and 2.5 to 4 mm in diameter at base), yellowish-green bark, deltoid-orbicular sepals 1 to 1.5 mm long, wider than long, obscurely denticulate, petals not more than 4.5 mm. long, and filaments not more than 3.5 mm long. It flowers later than var. *tenuispina,* from July to October (exceptionally in May). There is an early-flowering form in Texas (var. *verniflora* Bogusch), but this has much shorter spines than var. *tenuispina.*

Viola nephrophylla Greene var. **arizonica** (Greene), comb. nov.

Viola arizonica Greene, Pittonia **5**: 33. 1902.

This form differs, apparently, from typical *V. nephrophylla* only in having sparsely pubescent or at least ciliolate leaf-blades.

Chimaphila maculata (L.) Pursh var. **dasystemma** (Torrey), comb. nov.

Chimaphila dasystemma Torrey, in Rydb., North Amer. Flora **29**: 32. 1914.

This form differs from most eastern specimens of *C. maculata* in its shorter and relatively wide leaf-blades, these 2 to 4 cm long, one-third to two-thirds as wide.

Monotropa hypopitys L. var. **latisquama** (Rydb.), comb. nov.

Hypopitys latisquama Rydb., Bull. Torrey Club **40**: 461. 1913.

Compared with *M. hypopitys* as represented in the Eastern United States, this form differs in the usually pink or red color of the plant, taller and stouter stems, broader leaves (scales) and more numerous and larger flowers, with petals 10 mm long or longer.

Lysimachia ciliata L. var. **validula** (Greene), comb. nov.

Steironema validulum Greene, Contr. U. S. Nat. Herb. **16**: 158. 1913.

Differs from most eastern specimens of *L. ciliata,* and from *Steironema ciliatum* var. *occidentale* Suksdorf, in having the leaf-blades at most obscurely ciliolate, rather than distinctly short-ciliate. The blades also are narrower than they are commonly in *L. ciliata.* The petioles are conspicuously ciliate, as in other forms of the species.

Amsonia tomentosa Torrey and Frém. var. **stenophylla,** var. nov.

Folia 5–8 mm lata, inferiora distincte brevi-petiolata lamina rhomboideo-lanceolata, superiora lineari-lanceolata fere sessilia; folliculi maturi pubescentes vel glabrescentes.

Type: *Peebles & Fulton* 11944, Monument Valley, Navajo County, Ariz., altitude 5,300 feet, in flower June 4, 1935 (U. S. National Herbarium No. 1634559). Occurs also in the "Colorado Canyon" (*Mrs. Thompson* in 1872), and at Cameron, Coconino County, altitude 5,000 ft. (*Hanson* 160).

The Hanson collection was referred to *A. arenaria* Standley by Woodson

(Ann. Missouri Bot. Garden **15**: 424. 1928), but the writers believe it to be nearer *A. tomentosa*, since the leaves of *A. arenaria* are all very narrowly linear-lanceolate and sessile or subsessile. From typical *A. tomentosa* this variety differs in its narrower leaves and in the less copiously pubescent, or glabrescent, mature pods.

Mellichampia sinaloensis (Brandegee), comb. nov.

Roulinia sinaloensis Brandegee, Zoe **5**: 243. 1908.

This species differs from *M. ligulata* (Benth.) Vail (*M. rubescens* A. Gray) in having smaller, ochroleucous flowers, narrower and less pubescent corolla-lobes, corona-segments subquadrate at base and abruptly contracted into the subulate terminal portion (not gradually attenuate as in *M. ligulata*), and rounder, suborbicular or reniform anther-tips, these not or but slightly surpassing the stigmatic disk.

Gilia aggregata (Pursh) Spreng. var. **macrosiphon,** var. nov.

A *G. aggregata* f. *typica* corolla pallide purpureo-incarnata, lobis purpureo-maculatis, tubo cum fauce 3.5–4 cm longo, siccitate fauce ad apicem minus quam 3 mm lato, lobis caudato-acuminatis, distinguitur.

Type: *Peebles, Kearney, & Harrison* 2522, Santa Catalina Mountains, Pima County, Ariz., altitude 7,500 feet (U. S. National Herbarium No. 1367907). Known only from the type locality, where it is fairly abundant and where no other form of *G. aggregata* has been observed.

The very long narrow corolla and its purplish-pink color distinguish this variety from other forms of *G. aggregata*, in which the corolla rarely exceeds 3 cm. in length, is 3 to 4 mm wide at the throat in pressed specimens and varies in color from bright (spectrum) red to eosine pink.

Scutellaria tessellata Epling, sp. nov.[7]

Herba perennis altitudine plerumque 30–50 cm caulibus paucis e caudice lignoso ramoso ascendentibus utrimque pilis decurvis vix tamen appressis quam *S. wrightii* majoribus nisi glandulis sessilibus inconspicuis nullomodo glandulosis; calycibus rarius pilis extensis capitatis sparse conspersis; foliorum laminis *ovatis*, mediis 11–24 mm longis, 6–17 mm latis, petiolis 1–6 mm longis elatis, in apice obtusis in basi cuneato-angustatis etiam truncatis pilis extenso-decurvis hirtellis; calycibus glandulis inconspicuis sessilibus conspersis et pilis extensodecurvis rarius glandulosis hirtellis, labia inferiore 3–4.5 mm longa in maturitate paulo aucto, squama circiter 4.5 mm alta; corollarum violacearum galea cum tubo 12.5–19 mm longo, galea intus sparse piloso, *tubo ad calycis os piloso-annulato*, staminibus supra tubi basim 4–8 mm magnam partem circiter 5 mm positis, labia inferiore sparsissime pilosa; nuculis fuscis *tessellatis* quam *wrightii* etiam *resinosae* majoribus.

Type collected in the Huachuca Mountains by Marcus E. Jones, Sept. 3, 1903 (U. S. National Herbarium No. 856971). The species occurs in southern New Mexico and in central and southern Arizona, ranging in the latter state from near Ash Fork, Yavapai County, to the mountains of Cochise and Pima Counties, where it is especially abundant.

This species is distinguishable from *S. resinosa* and *S. wrightii* by the taller, more diffuse habit, the coarser pubescence, the ovate leaves, which are usually distinctly petioled, and the hairy annulus in the corolla tube. The nutlets are larger and the protuberances are flattened, giving a tessellate

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[7] Contributed by Carl Epling, University of California at Los Angeles.

appearance somewhat as in *S. canescens.* It is readily distinguished from *S. potosina* by the small decurved hairs.

Agastache barberi (Robinson) Epling, comb. nov.[7]
Brittonastrum barberi Robinson, Proc. Amer. Acad. **43**: 24. 1907.

Agastache breviflora (A. Gray) Epling, comb. nov.[7]
Cedronella breviflora A. Gray, Proc. Amer. Acad. **20**: 309. 1885.
Brittonastrum breviflorum Briq.; Engler & Prantl Pflanzenfam. Nachtr. **1**: 291. 1897.

Monardella arizonica Epling, sp. nov.[7]

Herba perennis saxicola suffruticosa 30–50 cm alta caulibus numerosis assurgentibus pilis brevibus decurvis et praesertim longioribus ad 1 mm longis extensis vestitis; foliorum laminis subsessilibus magnam partem lanceolatis 12–25 mm longis, 5–12 mm latis acutis integris, utrimque pilis extensis sparse conspersis et brevibus capitatis glandulosis; capitulis subnudis, bracteis angustioribus acutis calyces vix aequantibus; calycibus extus capitato-glandulosis et pilis longioribus extensis conspersis; corollis albis purpureo-maculatis.

Type collected by the author and Mrs. Epling in the Sierra Estrella, Maricopa County, Ariz., deposited in the herbarium of the University of California at Los Angeles. The species has been collected also in the Kofa Mountains, Yuma County, Ariz. (*Kearney & Peebles* 14220).

In an earlier paper (Ann. Missouri Bot. Gard. **12**: 1–106. 1925) for want of sufficient evidence to do otherwise, the author referred to *M. linoides* A. Gray several species proposed by E. L. Greene: *M. anemonoides, M. epilobioides, M. oblonga,* and *M. viminea.* Since this time evidence has been accumulating to suggest that each of these proposed species, as well as *M. robisonii* Epling, the species here proposed, and two other probable entities not as yet named, form a complex of closely related localized species. Each apparently is ecologically different, inasmuch as the associations in which they occur are different, and each is morphologically different, although these differences are slight and not always constant. Under cultivation, these distinctions are usually increased. When further evidence has accumulated as to the range of variation of each, as well as their cytology, it is hoped to present their relationships and distribution more fully.

The plants from the Kofa Mountains and the Sierra Estrella seem certainly to be the same. They occur there, growing from under large granitic boulders in much the same way as *M. robisonii,* which is confined to the region of Key's Ranch near Twenty-nine Palms, Calif., and which they most closely resemble. They are found in the *Larrea* climax associated with *Encelia farinosa, Fouquieria splendens, Salvia mohavensis* and *Hyptis emoryi.* In habit they are characterized by the rather broad leaves (for this species group), which tend to spread. The spreading pubescence is similar to that of *M. robisonii* but more pronounced.

Plants from the Ute Mountains, Ariz., however, more nearly suggest *M. epilobioides,* which is confined to the San Bernardino Mountains, Calif. They, too, grow from under boulders in the stream bed, with much the same habit as the plants from the Sierra Estrella, but the leaves are narrow, seldom more than 5 mm broad, and are ascendent, similar to those of *M. epilobioides.* The pubescence is shorter and that of the calyces is wholly glandular; in this respect also they are more like *M. epilobioides.* Their associates are somewhat different, as they occur at the margin of the juniper belt with

Salvia carnosa subsp. *argentea*, *Salvia mohavensis*, *Yucca mohavensis*, *Rhus anisophylla*, *Quercus turbinella*, *Garrya flavescens*, and *Rhamnus* sp. Both forms are found growing with *Salvia mohavensis*, which is known from Arizona from only one other locality. But these are the associates of *M. robisonii* rather than those of *M. epilobioides*, which is usually found at the lower margin of the yellow pine belt, on the desert side, often growing amongst the pine needles.

Penstemon angustifolius Nutt. ex Pursh subsp. **venosus** Keck, subsp. nov.[8]

Subsp. *caudatus* similis; bracteis lanceolatis ovatisve utrinque venosis nec nigrescentibus pallidis glaucis; corolla roseo-lilacina venis intus purpureis 15–20 mm longis; capsula 10–15 mm longa.

Type: *R. H. Peebles & H. J. Fulton* 11877, from 12 miles northeast of Tuba City, Coconino County, Ariz., at 5,300 feet elevation, June 3, 1935 (United States National Herbarium).

Specimens examined: ARIZONA: Apache County: 20 miles northeast of St. Johns, *Hope, King, & Harlan* 9321 (US); 4 miles northeast of Sweetwater, *Peebles & Smith* 13552 (CI, US); 9 miles northeast of Rock Point, *Peebles & Smith* 13530 (US). Navajo County: Jeddito Mesa, 1934, *Bartlett & Colton* (CI); Keams Canyon, *Hope, King, & Harlan* 9377 (US); Oraibi, *Whiting* 1272 (CI); Polacca-Winslow road, *Whiting* 795 (Mus. N. Ariz.). Coconino County: Klethla Valley, *Eastwood & Howell* 6505 (CAS); 23 miles north of Red Lake, *Peebles & Smith* 13894 (Sacaton); 6 miles east of Tuba City, 1901, *Ward* (US); Moencopi Sand Hill, 1934, *Colton & Bartlett* (CI). NEW MEXICO: San Juan County: Cedar Hill, *Standley* 7955 (US); Aztec, *Baker* 603 (GH, NY, RM, US); Bloomfield, *Waring* 27 (Ph); Farmington, *Standley* 6963 (US); plains west of Farmington, *Osterhout* 6960 (RM). UTAH: Grand County: between Moab and Castleton, *Cottam* 5618 (CI, Univ. Utah). San Juan County: Between Blanding and Bluff, *Stanton* 1021 (Ph); Bluff, *Cottam* 5585 (Univ. Utah), 5786 (CI, Univ. Utah); San Juan River, 10 miles northwest of Mexican Hat, *Maguire* 16260 (CI, Utah State). Garfield County: Escalante, *Cottam* 4385 (CI, Univ. Utah), *Stanton* 1022 (Ph). Millard-Juab County: Millard Sand Dunes, *Stanton* 5281 (Univ. Utah).

This subspecies is a rather constant plant of sand dunes. It grades over by fine steps into subsp. *caudatus* in western New Mexico, but it may usually be distinguished by the smaller, often pinkish flowers and the more venose bracts, which do not turn blackish in drying.

Penstemon angustifolius subsp. **caudatus** (Heller) Keck

Penstemon caudatus Heller, Minnesota Bot. Stud. **2**: 34. 1898.
P. angustifolius var. *caudatus* Rydb., Bull. Torrey Club **33**: 151. 1906.
P. secundiflorus caudatus A. Nels., in Coult. & Nels., New Man. Bot. 444. 1909.

Penstemon pachyphyllus A. Gray ex Rydb. subsp. **congestus** (Jones) Keck

Penstemon acuminatus Dougl. (var.) *congestus* Jones, Proc. California Acad. II, **5**: 714. 1895.
Penstemon congestus Pennell ap. Graham, Ann. Carnegie Mus. **26**: 331. 1937.

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[8] This and the other new subspecies and combinations in *Penstemon* contributed by David D. Keck, Carnegie Institution of Washington, Stanford University, Calif.

Penstemon virgatus A. Gray subsp. **arizonicus** (A. Gray) Keck

Penstemon hallii A. Gray var. *arizonicus* A. Gray, Syn. Fl. **2**(1): 263. 1878.

Penstemon strictus Benth. subsp. **strictiformis** (Rydb.) Keck

Penstemon strictiformis Rydb., Bull. Torrey Club **31**: 642. 1905.

Penstemon ambiguus Torr. subsp. **laevissimus** Keck, subsp. nov.

Planta undique glaberrima nitida.

Type: *I. W. Clokey* 8113, from Wilson's Ranch, Charleston Mountains, Clark County, Nev., at 1,180 m. elevation, in gravelly soil, with brush, in the *Larrea* belt, June 7, 1938 (Dudley Herbarium of Stanford University).

Typical *P. ambiguus* comes from Colorado. Its stems and usually the leaves are finely puberulent in contrast to the present subspecies in which the herbage is glabrous throughout. The two forms occupy adjacent ranges; the typical form is found on the plains of eastern Colorado, adjacent Kansas and southward through the panhandle of Texas, while subsp. *laevissimus* ranges from southwestern Texas northwesterly across central New Mexico and northern Arizona to southern Utah and Nevada.

Penstemon eatonii A. Gray subsp. **undosus** (Jones) Keck

Penstemon eatonii var. *undosus* Jones, Proc. California Acad. II. **5**: 715. 1895.
P. coccinatus Rydb., Bull. Torrey Club **36**: 691. 1909.

Penstemon eatonii subsp. **exsertus** (A. Nels.) Keck

Penstemon exsertus A. Nels., Amer. Journ. Bot. **18**: 438. 1931.
P. amplus A. Nels., *ibid.* **25**: 115. 1938.

Penstemon barbatus (Cav.) Roth subsp. **torreyi** (Benth.) Keck

Penstemon torreyi Benth. in DC., Prodr. **10**: 324. 1846.
P. barbatus var *torreyi* A. Gray, Proc. Amer. Acad. **6**: 59. 1862.

Penstemon barbatus subsp. **trichander** (A. Gray) Keck

Penstemon barbatus var. *trichander* A. Gray, Proc. Amer. Acad. **11**: 94. 1876.
P. trichander Rydb., Bull. Torrey Club **33**: 151. 1906.

Mimulus cardinalis Dougl. var. **verbenaceus** (Greene), comb. nov.

Mimulus verbenaceus Greene, Leaflets **2**: 2. 1909.

This form apparently differs from typical *M. cardinalis* only in having the corolla-tube more exserted (often nearly twice as long as the calyx) whereas in the typical form the tube is scarcely to moderately exserted; but the intergradation between these forms is practically complete.

Castilleja patriotica Fernald var. **blumeri** (Standley), comb. nov.

Castilleja blumeri Standley, Muhlenbergia **5**: 46. 1909.

Seems not to differ from typical *C. patriotica* except in the smaller size of the flowers: calyx about 20 mm long, corolla less than 30 mm long, galea less than 20 mm long. Specimens intermediate in size of flower also occur.

Cordylanthus wrightii A. Gray var. **pauciflorus,** var. nov.

A *C. wrightii* f. *typica* caulibus et foliis obscure puberulentibus vel glabrescentibus, capitulis uni-vel bifloris distinguitur.

Type: *Kearney & Peebles* 12884, 14 miles northeast of Tuba, Coconino County, Ariz., altitude 5,400 feet, September 27, 1935 (U. S. National

Herbarium No. 1651321). Occurs also in Navajo County, Ariz., in Keam Canyon (*Hough* in 1897, *Monson* in 1937), and on Jedito Mesa (*Zuck* in 1897).

Sambucus racemosa L. var. **microbotrys** (Rydb.), comb. nov.

Sambucus microbotrys Rydb., Bull. Torrey Club **28**: 503. 1901.

The glabrous or nearly glabrous branchlets and leaves and the more frequent occurrence of 7 leaflets seem to be the only characters distinguishing this form of the Rocky Mountain region from the form of *S. racemosa* (*S. pubens* Michx.) that occurs in the Eastern United States.

Sambucus neomexicana Woot. var. **vestita** (Woot. and Standl.), comb. nov

Sambucus vestita Woot. and Standl., Contr. U. S. Nat. Herb. **16**: 175. 1913.

The writers can find no character except the persistently puberulent or tomentulose herbage to distinguish *vestita* from *neomexicana*.

BOTANY.—*A new variety of the willow* Salix glaucophylla *Bebb.*[1]

CARLETON R. BALL, U. S. Department of Agriculture.

Recently the writer received from Dr. Otto E. Jennings, curator of botany in the Carnegie Museum at Pittsburgh, their Pennsylvania Salices for determination and verification before use on the State distribution maps. Among the specimens were some 40 sheets, mostly from Erie County, which represent a hitherto unrecognized variety. Curiously enough, the earliest collection had been made 60 years ago, in 1879, and nearly all are more than 30 years old.

At first glance the plant seems to be a robust and very hairy *S. cordata*, with the broad, cordate leaves of Muhlenberg's type. In fruiting characters, however, it is like *S. glaucophylla* Bebb, a sand-dune plant of the western Great Lakes area. This new form is regarded as a variety of that species.

Salix glaucophylla Bebb, **albovestita** Ball, n. var.

Straggling, divaricately branched shrub, 1–2.5 or 3 meters high; branchlets stout, yellowish brown to reddish brown to darker, often drying black, the seasonal shoots densely white-pilose, the 1-year and 2-year branchlets more or less gray-pubescent or puberulent to glabrous, dull; bud scales stout, ovoid or ovoid-lanceolate, 5–7 or 10 mm long, colored and clothed as the subtending branchlets; stipules semiovate to broadly reniform, 0.5–2 cm long, to 1 cm. wide, rounded to acutish or acute at apex, subentire to shallowly crenulate-serrulate, colored and clothed as the leaf blades.

Leaves stipulate, petiolate, unfolding with the aments; petioles 7–15 or 20 mm long, stoutish, channeled, pubescent; blades lanceolate to broadly lanceolate, ovate-lanceolate, or sometimes ovate, rounded to deeply cordate at base, short-acuminate to acuminate at apex (narrowly to broadly elliptical and acute at both ends while unfolding), 7 or 8 to 10 or 12 cm long and

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[1] Received July 22, 1939.

2–3 or 4 cm wide on ordinary seasonal shoots, averaging smaller on fruiting twigs and much larger up to 15 cm on vigorous shoots and sprouts, closely (6–10 projections per cm) to less closely (2–5 projections per cm) and sharply to shallowly crenate-serrate to subentire (all on one shoot), dark green and dull above (or darkening in drying) and glaucous to white-glaucous beneath when fully unfolded, thickish, finely to coarsely reticulate with raised veins on both surfaces at maturity (as in *S. cordata* and *S. glaucophylla*), densely to thinly white-pilose on both surfaces when unfolding, becoming less so by expansion, and finally glabrate at maturity except for pubescent petioles, midveins, and sometimes the laterals, on both surfaces and especially above.

Aments short-pedunculate, ascending to spreading, appearing with the leaves.

Staminate aments 2.5–3.5 or 4 cm long, 1–1.3 or 1.5 cm wide, dense, deciduous when the leaves are half grown; the peduncles stout, densely pilose, 0.5–1.0 cm long and bearing 2–4 or 5 oblong or elliptical, entire or subentire, glabrate, green, leaflike bracts 1–2 cm long; flower scales obovate or the lower oval, obtuse, 1.3–2 mm long, dark brown or blackish, densely pilose with straight hairs longer than the scale; stamens 2, filaments free, about 5 mm long, sparingly pubescent on the lower fifth to half; anthers oval, yellow, the stamens sometimes browning in drying.

Pistillate aments 3 or 3.5–5 cm long and 12–16 mm wide in anthesis, rather lax, becoming 4 or 5–7 or 8 cm long and 2.0–2.4 cm wide in fruit; peduncles as in the staminate but 0.8–1.5 cm long and bearing 2–4 elliptical, entire to shallowly crenulate-serrulate, leaflike bracts 1–2.5 or 3 cm long and 0.6–1.0 cm wide; flower scales brownish to black, 1.3–2 mm long, narrowly to broadly obovate, obtuse or occasionally acutish, densely clothed with straight hairs exceeding the scale in length; gland 1, filiform, capitate, 0.7–1 mm long; capsules lanceolate and 4–5 mm long in anthesis, becoming 6–9 mm long, broadly lanceolate from a round base, and brown in fruit, glabrous; pedicels 1.5–2.5 mm long in anthesis, 2–3 mm long in fruit, glabrous, stoutish, becoming brown; styles stoutish, 0.5–0.8 mm long, stigmas short, divided.

Variety *albovestita* differs from *S. glaucophylla* in broader, more cordate, and more acuminate leaves, and in hairiness. The blades are more definitely lanceolate, with rounded to deeply cordate bases and short-acuminate to acuminate apexes. In the species the leaves mostly are oblanceolate or elliptic-lanceolate, acutish to rounded but seldom cordate at base (except in var. *latifolia*), and are merely acute to short-acuminate at apex. In var. *albovestita* the young shoots are more or less densely white-pilose. This applies to branchlets and bud scales and to the petioles, midribs, and sometimes the lateral veins of full-grown leaves. During expansion both stipules and leaf blades usually are covered with white hairs. In the species the young branchlets often are gray-pubescent, but the other organs named usually are glabrous or glabrate. The filaments likewise are hairy in the variety and glabrate or glabrous in the species.

From *S. cordata* the new variety is separated by larger aments and capsules, longer scale hairs, and longer styles, as well as by broader leaves, and denser hairiness. From *S. adenophylla* this variety is readily separated by the longer and more acuminate leaves, loosely crenate-serrate, and becoming glabrate except on the midveins. In *S. adenophylla* the leaves are more nearly ovate, closely beaded on the margin with small, almost perpendicular, gland-tipped teeth, and permanently densely hairy.

DISTRIBUTION AND HISTORY

This variety occurs along the south shore of Lake Erie at least from northwestern Pennsylvania to north-central Ohio. A single typical collection has been made in Beaver County, Pa., near the Ohio River northwest of Pittsburgh and about 100 miles south of the lake. Sterile specimens from Lake Huron and from the mountains of southwestern Virginia are very similar. Possibly this represents a relic of a once wider distribution.

This variety is the Cedar Point, Ohio, willow listed by Werner (4) and Kellerman and Werner (3) as "intermediate between *S. cordata* and *S. adenophylla*" and the Erie County, Pa., willow discussed and illustrated by Griggs (1) as *S. adenophylla* and by Jennings (2:348–56) as *S. syrticola.* Griggs's description and right-hand shoot in plate 14 are true *adenophylla* (but not from Lake Erie), but his final paragraph, the left-hand figures in plate 14, and the enormous leaf in the center of plate 13 (*S. cordata*) are of this variety.

Specimens examined are listed below. Containing herbariums are designated by initials, as follows: CM, Carnegie Museum; CRB, Carleton R. Ball; OES, Ohio Agricultural Experiment Station; OSU, Ohio State University; USN, U. S. National Herbarium; VPI, Virginia Polytechnic Institute.

PENNSYLVANIA: *Erie County*: Presque Isle (unless otherwise stated), all CM.

Staminate flowering: Otto E. Jennings, May 15, 1905 (2 sheets, Acc. No. 2898); *Jennings,* May 8–9, 1906 (8 sheets, Acc. 3130, STAMINATE TYPE), *Gustave Guttenberg,* see below.

Pistillate flowering: Gustave Guttenberg 2621a, Cummins's Bank, Apr. 28, 1879 (Acc. 251, bearing both staminate and pistillate twigs); *Jennings,* May 8–9, 1906 (5 sheets, Acc. 3130, PISTILLATE TYPE).

Pistillate fruiting: Guttenberg 2621, May 28, 1879 (Acc. 251); *Jennings,* May 15, 1905 (Acc. 2898); *Guttenberg* (old fruit), June 11, 1881 (Acc. 251); *Jennings* (old fruit), June 8–9, 1906 (Acc. 3130; *Jennings* (old fruit), June 2–3, 1908 (6 sheets, Acc. 3711).

Foliage: Gustave Guttenberg 2626?, Big Bend, Presque Isle, Aug. 4, 1882 (Acc. 251); *J. A. Shafer,* Sept. 9 (2 sheets), Sept. 10 (enormous ovate leaves to 5.7×13 cm.), Sept. 11 (4 sheets, one with enormous ovate leaves to 6.3×15 cm), Sept. 12, 1900 (all Acc. No. 1560); *Otto E. Jennings,* Aug. 24, 1905 (Acc. No. 2898); *Jennings,* Sept. 20–22, 1906 (2 sheets, Acc. No. 3130); *James R. Farrell,* just back of Winter Wave Strand, July 15, 1930 (as *S. rostrata,* glabrate, Acc. No. 10127); *B. H. Patterson,* Northeast, Erie County, Aug. 22, 1908 (2 sheets, glabrate, Acc. No. 6210).

Beaver County: Ravine, Beaver, abundant in woods and roadsides, *W. R. Van Dersal* 1229, May 3, 1930 (Acc. No. 10571, CM).

OHIO: *Erie County:* Castalia, *R. F. Griggs* 638a, July 10, 1900 (OSU, as *S. cordata* × *candida*). Cedar Point, *A. D. Selby* 1449, 1450 ("7 ft, densely woolly"), 1451 ("4 ft., densely woolly"), 1456 ("4–5 ft"), 1458 ("8–10 ft"), all May 18, 1900 (all OES); on a sand dune, *Griggs*, Aug. 14, 1900 (OSU, as *S. cordata*, sprout with leaves up to 6.5–7 cm wide and more than 15 cm long; also in CRB); *F. O. Grover*, June 9, 1902 (OSU, as *S. cordata*); *Griggs*, June 28, 1904 (2 sheets, as *S. adenophylla*, OSU).

The following sterile specimens are referred somewhat doubtfully to the new variety, pending collection of fruiting material from these or other localities remote from Lake Erie:

MICHIGAN: *Huron County:* Single clump of small sprouts 3–4 ft high on land side of second row of dunes on Sand Point, Bay Port, *C. R. Ball* 70b, Sept. 17, 1902 (CRB, as *S. glaucophylla*).

VIRGINIA: *Roanoke County:* Back Creek, near Starkey, "much whiter looking than ordinary willow," *J. Fauntleroy* 663, Aug. 8, 1914 (USN, as *S. cordata*). The leaves are rather large, lanceolate, cordate at base, closely beset with incurved teeth, branchlets white-pilose, also the bud scales, petioles, midribs, and blades of younger leaves.

Montgomery County: Norris Run, near New River, *A. B. Massey*, Sept. 28, 1938 (VPI, as *S. cordata*), the leaves white pubescent and white-glaucous.

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MEDICAL ENTOMOLOGY.—*Mosquito transmission of encephalomyelitis, or brain fever, of horses.*[1] F. C. BISHOPP, U. S. Bureau of Entomology and Plant Quarantine.

The well-recognized economic importance of mosquitoes has been further emphasized by the recent discovery that these insects are capable of transmitting equine encephalomyelitis, or brain fever, of horses. This malady has appeared periodically for many years in outbreak proportions in various parts of the United States, although until recently the disease has not been clearly differentiated from forage poisoning.

The disease is caused by a minute organism so small that it can not be seen with the highest-power microscopes, and it passes through the clay filters that catch and hold the germs responsible for most diseases.

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[1] Read before the 13th Annual Meeting of the Florida Anti-Mosquito Association, Daytona Beach, Fla., April 17, 1939. Received May 27, 1939.

There are recognized at present two rather distinct types of the disease, usually spoken of as the eastern and western. The former is confined to the Eastern Seaboard and is generally acute, producing a mortality of 80 to above 90 percent. The western type is less severe, the mortality usually being about 20 percent.

The economic losses due to the disease are very heavy, and practically all parts of the country have felt the blow. For instance, the Bureau of Animal Industry, United States Department of Agriculture, has collected records of 184,662 cases in 1938 in 39 States, with a mortality for the entire country of 21.4 percent, or a death loss of about 39,518 horses and mules. Florida was among these States. The cases reported in this State were few but the mortality was high. The loss due to the occurrence of the disease among horses during 1938 may be conservatively placed at $10,000,000. In 1937, 173,889 cases were reported in 37 States, with a mortality in different areas ranging from about 20 percent in most western States to 100 percent in some eastern and southern States.

One of the most severe and widespread epizootics of the disease occurred in 1912. This outbreak reached its most devastating proportions in central and western Kansas and Nebraska, where the death loss was estimated at 35,000 head. Epizootics appear to recur at intervals of 10 to 15 years, with numerous sporadic or enzootic appearances between. The losses are intensified by the fact that work animals are often stricken in the midst of harvest, and in not a few cases a farmer has lost every animal at that critical period.

The importance of the disease and of mosquitoes that might serve as carriers of it was further emphasized by the determination last year that encephalomyelitis of horses is transmissible to man. L. D. Fothergill and associates[2] demonstrated the presence, in the brain of a child who had died of acute encephalitis, of a virus indistinguishable from the eastern type of encephalomyelitis which appeared among horses in Massachusetts during the summer of 1938. This identification was confirmed by L. T. Webster and F. H. Wright,[3] who described similar findings in four other fatal human cases. The diagnosis of the first case referred to above was further confirmed by H. W. Schoening, L. T. Giltner, and M. S. Shahan.[4]

R. F. Feemster,[5] of the Massachusetts Department of Public Health, published a general account of the outbreak in Massachusetts

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[2] New England Journ. Med. **219**: 411. 1938.
[3] Science **88**: 305–306. 1938.
[4] Science **88**: 409–410. 1938.
[5] Amer. Journ. Public Health **28**: 1403–1410. 1938.

with comment on its relation to the epizootic among horses in that State. He points out that there is "a universal history of mosquito bites" among the cases investigated. He states also that no connection between cases indicating contact infection has been traced and that no contact at all with horses could be discovered in some of the cases. The incidence was high among children, 37 percent being under 2 years of age and 69 percent under 10 years. The mortality was high. Death occurred in 25 of the 38 cases definitely diagnosed as being caused by the eastern virus of encephalomyelitis or strongly suspected of being that disease.

In November 1938, C. M. Eklund and Alex Blumstein[6] reported the occurrence in 1937 of six cases of encephalitis in farmers in Minnesota, the serum from one neutralizing equine virus of the western type. One of the farmers had had no contact with sick horses. Two of the men died.

The occurrence of the disease in horses has attracted most attention, but a number of other animals and birds have been shown to be susceptible to artificial exposure. Among these are sheep, cattle, rabbits, guinea pigs, pigeons, monkeys, rats, mice, and ducks. Recently E. E. Tyzzer, A. W. Sellards, and B. L. Bennett[7] demonstrated the occurrence of the disease in pheasants in nature, and many other species of birds have been found to be susceptible to virus diseases of this group. L. D. Fothergill and J. H. Dingle[8] found the disease in common wild pigeons not in confinement.

The onset of the disease in horses and man is sudden, and nervous symptoms are apparent almost immediately and become progressively more pronounced, clearly showing involvement of the central nervous system.

Although it was suspected that some insect might be responsible for the sudden appearance and rapid spread of the malady in a given locality, it was not until 1933 that R. A. Kelser[9] announced experiments in which the western strain of the disease was transmitted from guinea pigs to numerous other guinea pigs, and to a horse by the bite of the yellow-fever mosquito [*Aedes aegypti* (L.)]. He showed that the virus was picked up by the mosquitoes only when they were fed on the artificially inoculated animals 48 to 120 hours after these animals had been injected, or during the fever period.

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[6] Journ. Amer. Med. Assoc. **111**: 1734–1735. 1938.
[7] Science **88**: 505–506. 1938.
[8] Science **88**: 549–550. 1938.
[9] Journ. Amer. Vet. Med. Assoc. **82** (n.s. **35**): 767–771. 1933.

In 1934 M. H. Merrill, C. W. Lacaillade, Jr., and Carl Ten Broeck[10] reported experiments in which they had repeatedly transmitted the disease to healthy guinea pigs with the salt-marsh mosquito [*Aedes sollicitans* (Walk.)]. When the mosquitoes were fed on a guinea-pig brain, western virus suspension, and normal horse blood, they did not become infective until the seventh day. This mosquito transmitted the eastern type of the disease to healthy guinea pigs 11 days after the infective feeding and subsequently at least up to the thirty-third day. The authors also succeeded in transmitting the western virus with *Aedes aegypti* but failed to transmit the eastern type. They reported that a few tests with the brown salt-marsh mosquito [*Aedes cantator* (Coq.)] indicate that it will transmit the eastern virus. The northern house mosquito (*Culex pipiens* L.) and the common malaria mosquito (*Anopheles quadrimaculatus* Say) failed to transmit either type of the disease. These authors showed that in order to become infective the mosquitoes must feed on animals when the virus content of the blood is high and that the virus multiplies greatly in the mosquito. It has been shown that the virus is present in body fluids and in all parts of the body and even in the legs of mosquitoes.

In 1936 J. S. Simmons, F. H. K. Reynolds, and V. H. Cornell[11] published an account of the transmission of the western type under experimental conditions by *Aedes albopictus* Skuse, a preliminary announcement having been made in the Annual Report of the Surgeon General of the United States Army for 1934. This is an Asiatic species and hence can not have any part in the transmission of the disease in this country.

D. E. Madsen and G. F. Knowlton[12] proved that two common western species of mosquito, *Aedes dorsalis* (Meig.) and *A. nigromaculis* (Lud.), were capable of transmitting the western type of encephalomyelitis. The period during which the former species was infective was from 9 to 19 days after feeding on an infective animal, and in the latter from 4 to 10 days.

In 1937 R. A. Kelser[13] added the southern salt-marsh mosquito [*Aedes taeniorhynchus* (Wied.)] to the list of mosquitoes demonstrated to be capable of carrying the disease under experimental conditions. It is well known that this is the dominant salt-marsh mosquito in Florida.

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[10] Science **80**: 251–252. 1934.

[11] Amer. Journ. Trop. Med. **16**: 289–302. 1936.

[12] Journ. Amer. Vet. Med. Assoc. **86** (n.s. **39**): 662–666. 1935; *ibid.* **89** (n.s. **42**): 187–196. 1936.

[13] Science **85**: 178. 1937.

The following year Dr. Kelser[14] described some experiments with *Aedes vexans* (Meig.) in the transmission of the western type. He experienced difficulty in keeping the mosquitoes alive for a sufficient period to make a satisfactory test, but one guinea pig out of three exposed to the mosquitoes during a period of 8 or 9 days after an infective meal was stricken.

Thus a total of 8 species of mosquitoes have been proved to be capable of transmitting the disease; and it should not be concluded that others may not be involved, as relatively few other species have been tested.

The experimental results indicate that the period in which the virus is present in the blood and can be picked up by mosquitoes is distinctly limited. This period is very early in the course of the disease, and in the case of horses it is mainly prior to the appearance of marked clinical symptoms.

Although infective mosquitoes have not been found in nature and many attempts to transmit the disease with these insects have failed, circumstantial evidence, as well as experimental results, point strongly to mosquitoes as carriers. It is noteworthy that the disease outbreaks occur mainly in summer and early in fall and are usually associated with great mosquito abundance and in the East with rainy or humid weather. The disease in the East is rather closely limited to the areas where salt-marsh mosquitoes occur. In the arid West it is closely associated with irrigated areas where mosquitoes abound. Some cases in winter have been reported, but diagnosis, at least in certain of these, is open to question, and in some of these instances it had not been possible to debar mosquitoes, for, as is well known, mosquitoes may be active in winter in warm barns and during warm periods.

In this connection attention is directed to a case in a horse at Ocala, Fla., which died on January 13, 1939. The brain of the animal was submitted by E. F. Thomas, of Ocala, to the U. S. Bureau of Animal Industry, and O. L. Osteen,[15] of that Bureau, confirmed the diagnosis as encephalomyelitis of the eastern type. During the period immediately preceding the appearance of this case the weather was very warm, several degrees above normal, and mosquitoes were undoubtedly active.

With reference to the human cases of this disease it can be said definitely that several that occurred in 1938 in Massachusetts were in individuals who had not had any direct or indirect contact with

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[14] Journ. Amer. Vet. Med. Assoc. **92** (n.s. **45**): 195–203. 1938.

[15] Journ. Amer. Vet. Med. Assoc. **94** (n.s. **47**): 441–442. 1939.

horses, and some of them had had no association with any animal or bird. Some of the children, however, were reported as being "covered with mosquito bites" when admitted to the hospital.

The fact that a few cases of the disease appear among horses in May or June and a period of absence or practical absence of the malady intervenes, followed by a severe outbreak in August and September, leads one to wonder why the cases do not continue to increase right through the summer, and to raise the question as to where the disease holds over during such periods and also through the winter. Some have suggested that this carry-over may take place in some bird. As is well known, birds and poultry are freely attacked by mosquitoes. There is also the possibility that the virus may be kept alive in the mosquito or that it may be carried through the egg and larva from one generation to another. The tests with hereditary transmission conducted by L. T. Giltner and M. S. Shahan[16] have, however, been negative.

The fact that the virus is short-lived when exposed and that it will remain viable and multiply in mosquitoes also favors the mosquito theory of transmission. In cooperative tests carried on by the Bureau of Animal Industry and the Bureau of Entomology and Plant Quarantine[16] yellow-fever mosquitoes when fed on healthy guinea pigs produced the disease 7 to 74 days after being engorged on an infected animal.

The comparatively low incidence of the disease among horses kept in stables at night and among those which are sprayed with insect-killing or repelling materials has been noted by several authors, and fits in with the mosquito theory.

No species of mosquito has a distribution and a seasonal prevalence that coincide with the incidence of the disease. However, there is no reason to attach responsibility to a single species when several have been shown to be effective vectors. *Aedes vexans* is the most widely distributed of the proved vectors, and it is often very abundant and attacks horses and people viciously late in summer, when the peak of the disease usually occurs. Its presence in large numbers, however, is by no means restricted to late summer and fall. *A. dorsalis* is an extremely abundant species over much of the area in the central and western States where the disease has been prevalent. *A. nigromaculis* is much more restricted in distribution, being confined to the plains and irrigated areas from Texas to Canada and New Mexico to Idaho. It is a severe biter and at times becomes abundant. *A.*

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[16] Journn. Amer. Vet. Med. Assoc. **88** (n.s. **41**): 363–374. 1936.

sollicitans, as has been indicated, is often extremely abundant at the peak of an epizootic of the eastern strain and largely covers the area where that type is prevalent. The disease has been less prevalent in the area where the southern salt-marsh mosquito (*A. taeniorhynchus*) is abundant, and *A. sollicitans* is usually present along with that species. *A. aegypti* might play an important part in the transmission of the malady in the South, but this mosquito does not occur where the disease has been most prevalent. Since only one positive case of transmission of the eastern virus by this species occurred out of many attempts, it may be assumed that *Aedes aegypti* is not likely to be of importance as a vector, except in the South where the western virus is present, notably in Texas and Oklahoma. The reported lower incidence of the disease among stabled horses does not fit in with the building-inhabiting tendencies of this mosquito.

There is obviously much to be learned about this dangerous malady and the relation of insects to its transmission. However, while this information is being sought it seems logical to take action against mosquitoes and as far as practical to protect man and horses from mosquitoes and other biting insects, especially when the disease is present in the region.

ENTOMOLOGY.—*Nomenclatorial notes on Corrodentia, with descriptions of two new species of* Archipsocus.[1]

Ashley Buell Gurney, U. S. Bureau of Entomology and Plant Quarantine. (Communicated by C. F. W. Muesebeck.)

For the past several years Dr. T. E. Snyder, of the Division of Forest Insect Investigations, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, has noticed unsightly psocid webs on the trunks of trees at New Orleans, La. The psocid responsible for the webs belongs to a genus hitherto known, among living species, only in tropical regions, and probably it is an established adventive in this country. As the species does not seem to agree with the description of any previously known species, it is here described as new. A second new species of *Archipsocus,* collected in Panama by James Zetek, is also described.

The opportunity is taken to present various notes on the nomenclature of Corrodentia. While certain of these matters may remain open to debate until definitely settled by the International Commission on Zoological Nomenclature, it seems worth while to place the facts on record.

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[1] Received May 28, 1939.

Genus **Archipsocus** Hagen

Archipsocus Hagen, Stettin. Ent. Zeit. **43:** 222–225, pl. 1, fig. x, 1–10. 1882. (Genotype, *A. puber* Hagen, by monotypy.)

The genus *Archipsocus* was based upon a single fossil species, *puber*, from East Prussian amber. At the time of the original description only long-winged specimens were known. Enderlein (1911a) has since recorded a short-winged female of *puber* and has redescribed the genus (1903a, 1911a). Among the important generic characters are the following: Head subquadrate in dorsal view; compound eyes with many facets; antennae 13-segmented; prothorax distinct and free; wings rudimentary or as long as body, bearing setae and fine pubescence, venation of type illustrated by *nomas* (Figs. 4–6); tarsi 2-segmented; claws 2 in number, each with a ventral appendage. The excellent preservation obtainable in amber allows the close comparison of the structural details of the fossil genotype and the recent species. Details of the antennae and tarsi of *puber* illustrated in 1882 are remarkably like those of living species.

Temporarily, at least, the writer follows Banks (1929) in placing *Archipsocus* in the family Empheriidae (not Empheridae), but the latter's classification does not agree with those of Karny (1930) and Pearman (1936a), and a future change is anticipated.

The following recent species of *Archipsocus* have been described: *A. recens* Enderlein 1903a (Ceylon to Formosa); *A. brasilianus* Enderlein, 1906 (Brazil); *A. textor* Enderlein, 1911b (Africa); *A. neens* Enderlein, 1914 (West Africa); *A. fernandi* Pearman, 1934 (Ceylon); *A. biguttatus* Pearman, 1936b (Ceylon).

Archipsocus nomas,[2] n. sp. Figs. 1–14

Short-winged female.—General form (Fig. 1) typical of genus. Head with coronal suture and frontal sutures feebly indicated. Caudolateral angles of head with long curved setae. Compound eyes each with more than 20 facets. Median ocellus slightly smaller than lateral ocelli. Apical segment of maxillary palpus thrice as long as wide, twice as long as penultimate segment. Lacinia ("pick") (Fig. 8) curved at base, flattened and expanded in apical third, apex forked. Length of antennal segments 1–13 (Fig. 3) in the following ratio: 1:2:1.6:0.8:1:1:1:1:1:0.9:0.9:0.8:1.5. Laterocervical sclerite (Fig. 14) with articulatory projections along margin. Pronotum transverse, lateral margins rounded; each caudolateral angle bearing several curved setae. Front wing (Fig. 6) extending beyond tergum 1; venation much reduced. Hind wing reduced to a tiny lobe about as long as first tarsal segment. Legs (Figs. 10–12) as illustrated. Tibiae clothed with short setae, those at apex (Fig. 9) stout and spurlike. Each claw with a curved ventral appendage.

Abdomen clothed with fine setae, unsclerotized except terga 1–2 and genital segments. Genitalia as shown in Fig. 2 in ventral view. Sclerotized area of subgenital plate emarginate at base. Anterolateral lobes of tergum 9 strongly sclerotized and curving hooklike about bases of gonapophyses.

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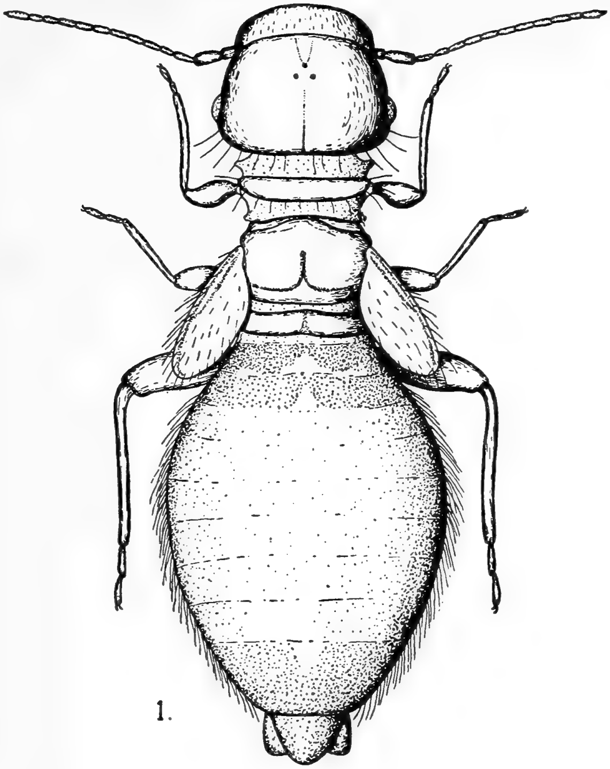
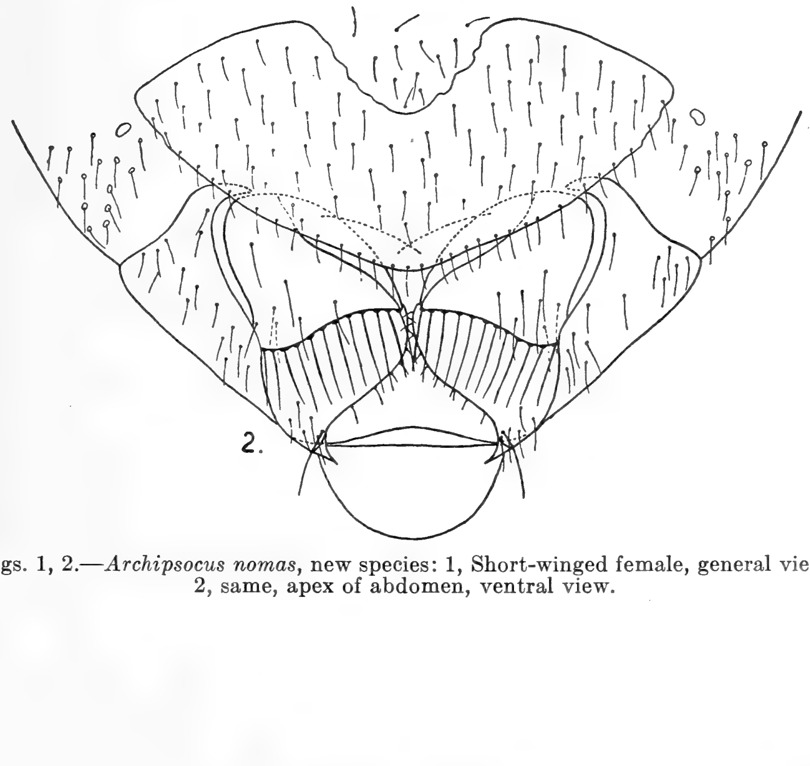
[2] From the Latin word meaning a nomad, in allusion to the fact that the present species is probably introduced from its original home.





Figs. 1, 2.—*Archipsocus nomas*, new species: 1, Short-winged female, general view; 2, same, apex of abdomen, ventral view.

Gonapophysis (Fig. 7) with middle third unsclerotized and in distinct contrast to well-sclerotized remainder, a heavy curved bristle borne near medial margin, setae borne on disk and posterior margin as illustrated. Posterior margins of paraprocts broadly rounded ventrally, dorsal margin less broadly, so that an acute apex of the latter appears when seen in ventral view. Supraanal plate broadly rounded, unspecialized.

Coloration: General color dark brown; compound eyes and ocellar triangle black; palpi, antennae, tibiae, and tarsi pale. Wing transparent, gray.

Measurements: Length of body 1.6 mm, of antenna 0.51 mm, of wing 0.42 mm, of hind tibia 0.42 mm; width of head 0.45 mm.

Long-winged female.—Differing from short-winged female only in structure of mesothorax and metathorax and in the presence of fully developed wings. Lateral tergal lobes of mesonotum and metanotum well developed to accommodate muscles of flight. Wings with venation as illustrated (Figs. 4, 5). Front wing entirely covered by setae; setae of hind wing not extending basad of apical half except along posterior margin.

Coloration: Dorsal sutures of thorax conspicuously dark, otherwise agreeing with short-winged female.

Measurements: Length of front wing 1.3 mm, of hind wing 1 mm; other measurements as in short-winged female.

Short-winged male.—Differing from female mainly in smaller size, vestigial ocelli, and genitalia. Ocelli not distinct, present only as tiny spots in same location as those of female. Front wing scarcely reaching posterior margin of tergum 1. Tergum 9 irregularly and feebly emarginate along anterior margin; lateral extremities broadly joined to lateral margins of posterior sclerite of subgenital plate (Fig. 13). Anterior sclerite of subgenital plate transverse, broadly emarginate anteriorly, deeply emarginate at lateral extremities. Phallic armament dorsad of subgenital plate visible through the latter as illustrated. Anterior ends of lateral arms flattened and joined; lateral arms entirely separated from posterior portion, which is V-shaped and pointed at the apex. Paraprocts well sclerotized dorsally only, so that when seen in ventral view (Fig. 13) the concave surface of the supraanal plate and the inner surface of tergum 9 are visible through the transparent ventral portion of the paraprocts.

Coloration: As in female.

Measurements: Length of body 1.4 mm, of antenna 0.43 mm, of wing 0.20 mm, of hind tibia 0.36 mm; width of head 0.37 mm.

Nymphs.—Ten immature specimens, representing both long-winged and short-winged forms, are at hand. The antennae are 13-segmented and tarsi 2-segmented in the specimens, which range from 0.7 to 1.5 mm in length. The smallest individuals have no wing pads. The coloration averages lighter than in the adults. The compound eyes are black.

Variation.—A few short-winged females intergrade in wing length with the long-winged form. The wings of 18 of these intergrading specimens are longer than normal for the short-winged condition, ranging from slightly longer than normal to 0.75 mm in length. Body size is remarkably constant in short-winged females; a few varying specimens range from 1.54 to 1.75 mm in body length. Throughout the series the female genitalia are constant in all important respects. The arrangement of setae on the gonapophyses varies slightly, but the total number of setae is seldom greater than illustrated (Fig. 2) and a condition corresponding to the description of *brasilianus* has not been found. Long-winged females range in body length from 1.6 to 1.9 mm and in wing length from 1.1 to 1.3 mm. The lateral margins of the basal sclerite of the male subgenital plate vary in outline from a simple curve (Fig. 13) to a broken, irregular condition. No other noticeable variation has been seen in the paratypic series.

Type locality.—Audubon Park, New Orleans, La.

Type.—U. S. N. M. No. 53218.

Holotype.—Short-winged male collected at the type locality by T. E. Snyder about October 5, 1938.

Allotype.—Short-winged female with same data as the holotype.

Paratypes.—Nine nymphs, 130 short-winged females, 16 long-winged females, and 18 males with same data as the holotype; 1 nymph, 115 short-winged females, 4 long-winged females, and 1 male taken at the type locality September 28, 1938; 9 short-winged females, 2 long-winged females, and 2 males taken by T. E. Snyder at the type locality August 22, 1938. Of the above paratypes, 10 short-winged females, 2 long-winged females, and 2 males are deposited in the Museum of Comparative Zoology, Cambridge, Mass. With the exception of a few slide-mounted specimens treated with potassium hydroxide, and potassium hydroxide plus stain, all the material is preserved in alcohol.

The previously described species most likely to be confused with *nomas* is *brasilianus.* The latter differs from *nomas* in the larger number of setae on the gonapophyses of the female and in the proportions of the antennal segments. The basal emargination of the anterior margin of the subgenital plate, the division of each gonapophysis into a sclerotized and an unsclerotized portion, and the presence of a large bristle on the median margin of each gonapophysis are conspicuous features of *nomas.* On the basis of Enderlein's figures of *brasilianus,* that species lacks these characters.

Archipsocus panama, n. sp. Fig. 15

The most noticeable difference between *panama* and *nomas* is found in the male genitalia (Figs. 13, 15). Other important differences in *panama* are smaller size and proportionally longer antennae as compared to other body structures. Unfortunately, the male of *brasilianus* has not been described, but, on the basis of Enderlein's measurements, this is a larger species than *panama;* the description of the female differs from that of *panama* as from that of *nomas.*

In color *panama* is slightly ligher than *nomas.* The following description is abbreviated because of the great similarity, except as noted, to *nomas:*

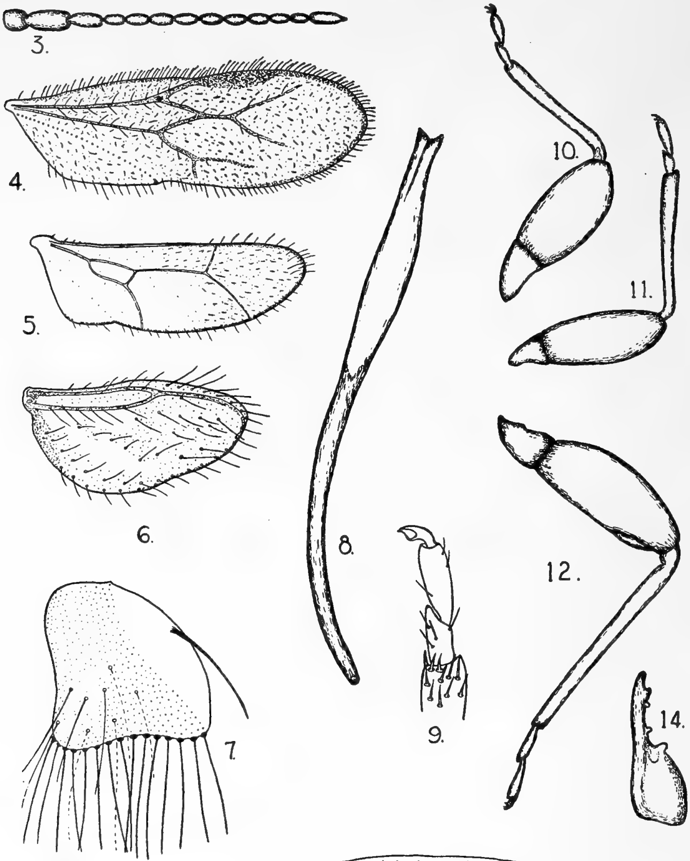
Short-winged female.—General form as in *nomas.* Lacinia with apical fork slightly more acute than in *nomas.* Length of antennal segments 1–13 in the following ratio: 1:1.6:1.4:1:1.1:1.1:0.8:1:0.7:0.9:0.7:1:1.3. Setae on abdomen little developed, less noticeable than in *nomas.* Gonapophysis of genitalia with curved bristle near medial margin less strongly sclerotized than in *nomas.*

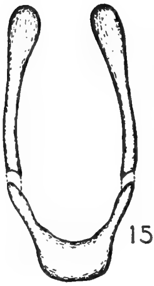
Measurements: Length of body 1.43 mm, of antenna 0.57 mm, of wing 0.19 mm, of hind tibia 0.33 mm; width of head 0.37 mm.

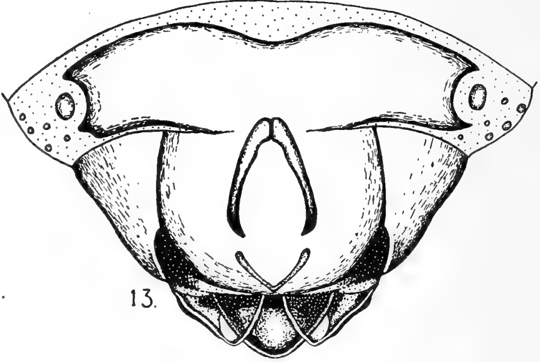
Long-winged female.—Differing from short-winged female only in same way as *nomas.* Wings as in *nomas.*

Measurements: Length of antenna 0.61 mm, of front wing 1.07 mm, of hind wing 0.93 mm, of hind tibia 0.36 mm; other measurements as in short-winged female.

Short-winged male.—Differing from female as in *nomas.* Phallic armament (Fig. 15) horseshoe-shaped; anterior ends of lateral arms expanded and flattened, but not united; separation between lateral arms and posterior







Figs. 3–14.—*Archipsocus nomas*, new species: 3, Short-winged female, left antenna; 4, long-winged female, right front wing; 5, same, right hind wing; 6, short-winged female, right front wing; 7, same, right gonapophysis, ventral view; 8, same, right lacinia; 9, same, tarsus and apex of tibia of middle leg, side view; 10, same, front leg; 11, same, middle leg; 12, same, hind leg; 13, short-winged male, apex of abdomen, ventral view; 14, short-winged female, laterocervical sclerite.

Fig. 15.—*Archipsocus panama*, new species: Short-winged male, ventral view of genitalia, anterior portion uppermost.

All drawings made by the author from paratypes except that of *panama* (Fig. 15), which is from the holotype.

portion indicated by weakened sclerotization, but not entirely separated as in *nomas;* apex of posterior portion broad and platelike, unlike *nomas* (Fig. 13).

Measurements: Length of body 1.05 mm, of antenna 0.53 mm, of wing 0.14 mm, of hind tibia 0.31 mm; width of head 0.32 mm.

Nymphs.—There are three nymphs, apparently females, in the instar immediately preceding maturity. The three specimens are of uniform size, 1.2 mm long, and very pale except for the black compound eyes. The wings are well developed and extend one-half the length of the abdomen.

Variation.—As the measurements indicate, the antennae and hind tibiae of the long-winged female appear to be proportionately longer than those of the short-winged female. Since only two of the latter have been studied, the differences may represent normal variation.

Type locality.—Barro Colorado Island, Canal Zone, Panama.

Type.—U. S. N. M. No. 53375.

Holotype.—Short-winged male collected at the type locality, March 24, 1939, by James Zetek.

Allotype.—Long-winged female with same data as the holotype.

Paratypes.—One short-winged male, three short-winged females, 17 long-winged females and three nymphs with same data as the holotype. Six paratypes are mounted on slides; the remaining material is in alcohol.

HABITS OF ARCHIPSOCUS

Dr. Snyder has kindly furnished the following notes concerning *Archipsocus nomas:*

"Early in July and August 1934 the extensive webs of this psocid attracted considerable attention in the parks and streets of New Orleans, and we received many inquiries with regard to it. The entire trunks of large live oak and hackberry trees were covered by tough webs, and this included some of the larger branches 20 or 30 feet above ground. Apparently the psocids were feeding on lichens which grow luxuriantly on the moist tree trunks in this damp climate.

"It was interesting to note how these extensive webs began. They first appeared as small islands on the trunks of trees, which islands of web gradually coalesced until the whole surface of the trunk completely around the tree was covered.

"The superintendents of various city parks and the Federal cemetery requested information as to how to control these insects which were making such unsightly webs on the trees. We recommended that the larger branches and trunks of the trees be scrubbed with oil emulsions. By the use of ladders and long-handled brushes, these control measures were adopted by the various city parks. Similar webs were found on shade trees along the nearby Gulf coast of Mississippi, and we received several calls from this region as to how to control the insects making the webs.

"No further webbing was observed until September 1937, when the same conditions as in 1934 prevailed. It is quite possible that the insect was present in small numbers during the interval, but if so it was not in sufficient numbers to be noticeable. In August 1938 this psocid again became so abundant that its webs became noticeable. Toward the end of September 1938 the insects became less numerous under the webs, the webs had become broken, and Argentine ants were carrying away quite a few of the insects."

The specimens of *Archipsocus panama* were associated with scale insects on twigs of "sigua" (either *Nectandra globosa* or *Ocotea cernua*, identification uncertain), one of the laurel family. More detailed information is lacking.

It is evident that the web-spinning habit of *nomas* closely parallels that of other species of *Archipsocus*. Enderlein (1903a) quotes a correspondent, Ludwig Biró, at length regarding the habits of *recens* at Singapore. Webs, about 15 to 30 centimeters broad and up to 6 to 8 meters long, were observed on tree trunks, and colonies of the psocids lived beneath the web, feeding mainly on algae, lichens, and other plants occurring on the bark enclosed by the web. Green (1912) has discussed *Archipsocus* webs found covering in profusion an orange tree in the Royal Botanic Gardens at Colombo, Ceylon. Pearman (1936b) states that the species reported by Green was *recens*. According to Green, the web serves mainly for protection, though he has observed an hemipteron and a thrips attacking the psocids. The silk comes from the mouth, and as the insects wander around, with no apparent design, a tangle of threads results. Enderlein (1912) discusses the webs of *recens* in detail, as described by a correspondent in Java. On citrus bushes and other plants the webs are frequent and extensive. Judged from photographs, they are similar to those of the eastern tent caterpillar (*Malacosoma americana* (F.)) in the United States. They envelop small branches, and hundreds of the psocids, mostly short-winged females, live beneath the webs. Protection from the attacks of ants was considered an important function of the web. When a web was partially removed, passing ants fell upon the helpless psocids at once.

Enderlein (1906) says that *brasilianus* has been collected from webs spun in the corners of the walls on a veranda of a house at Pará, Brazil. The species *textor*, *fernandi*, and *biguttatus* are web spinners (see Enderlein, 1911b; Pearman, 1934, 1936b), and *fernandi* is said to spin webs on the under surfaces of decaying leaves on the ground.

It is well known that many psocids cover their eggs with a thin, transparent layer of silk. Borgmeier (1928) has reviewed the principal literature of web-spinning psocids and described in detail the webs of *Epipsocus borgmeieri* R. Karny.

Two species of *Archipsocus*, *fernandi* and *biguttatus*, are of special interest since they are viviparous; according to Pearman (1936b) they are the only viviparous psocids known, and the females lack gonapophyses. Fernando (1934) has studied the embryology of *fernandi.*

NOMENCLATORIAL NOTES ON CORRODENTIA

Almost since the time of Linnaeus there has been a confused state of the nomenclature centering about two common and widespread species of book-lice, *Trogium pulsatorium* (L.) and *Liposcelis divinatorius* (Müll.). This confusion has had a bearing upon the nomenclature of certain psocids which are members of families other than the Trogiidae, as for instance the genus *Lachesilla* Westwood. For some years the name *Troctes divinatorius* (Müll.) has been employed by the Bureau of Entomology and Plant Quarantine, and as the name *Troctes* apparently can no longer be held valid it seems worth while to review in detail the facts concerned in the confusion. The information below is arranged chronologically under the genera involved.

Genus **Trogium** Illiger, 1798

1758 (p. 610), Linnaeus described *Termes pulsatorium.*

1761 (p. 474), Linnaeus treated *Termes pulsatorium,* with a reference to the work of 1758.

1775 (p. 311), Fabricius treated *Hemerobius pulsatorius,* with references to Linnaeus and other workers.

1778 (pp. 41–47, 868–869, pl. 4, figs. 1–4), Degeer described *Termes lignarium* and listed *pulsatorum* L. as an equivalent. Degeer's description applies mainly to the true *pulsatorium* L., but his figures make it evident that he had a mixed series. Of Degeer's illustrations, only fig. 1 represents *pulsatorium* L.

1781 (pp. 394–395), Fabricius treated *pulsatorius* and included a reference to "Degeer Ins. 7. 1. tab. 4. fig. 1."

1798 (p. 500), Illiger proposed *Trogium* as a new genus with one included species, *Hemerobius pulsatorius* F.

1928 (p. 179), Pearman objected to the name *Trogium,* saying that Fabricius's diagnosis of *pulsatorius* was insufficient and was followed by citations referring to both *pulsatorius* and *divinatorius.*

Conclusion.—*Trogium* is a valid genus, with *pulsatorium* L. as its type.

Discussion.—Fabricius's characterization of *pulsatorius,* though brief, certainly constitutes a description. In both publications he lists definite citations to Linnaean works. The reference in 1781 to "Degeer Ins. 7. 41. 1. tab. 4. fig. 1." is significant, for this figure depicts the true *pulsatorium* L., whereas Degeer's other figures are of certain other species. Thus Fabricius designated the particular figure which correctly represented *pulsatorium.* Under the circumstances Illiger's "*pulsatorius* Fabr." appears clearly to refer to the true Linnaean species, and a genotype of *Trogium* is considered to have been properly established.

Genus **Atropos** Leach, 1815

1758 (p. 610), Linnaeus described *Termes pulsatorium.*

1778 (pp. 41–48, 868–869, pl. 4, figs. 1–4), Degeer described *Termes lignarium* and listed *Termes pulsatorium* L. as an equivalent.

1815 (p. 139), Leach erected the genus *Atropos* with one species definitely included, *Termes lignarium* Deg. Leach considered that *Psocus fatidicus* F. was doubtfully a member of the genus *Atropos. Termes pulsatorium* L. and the *Psocus pulsatorius* of Fabricius, Latreille, and Coquebert were listed as equivalents of *Termes lignarium.*

Conclusion.—The type of *Atropos* is *lignarium* Deg. (a synonym of *pulsatorium* L.); accordingly, the genus is isogenotypic and synonymous with *Trogium* Illiger, 1798.

Discussion.—Degeer's description applies to true *pulsatorium* L. (judged from remarks describing the eyes and the reddish abdominal spots), and the first species cited is *Termes pulsatorium* L. Figure 1 is clearly *pulsatorium,* but the other figures and certain features presented in discussion are of both *divinatorius* and nymphs of certain winged psocids. While it is evident that Degeer possessed a mixed collection, his clear intention of basing *lignarium* on the same species as Linnaeus's *pulsatorium* and his citation of the Linnaean name fix his species as a synonym of *pulsatorium.* Thus the type of *Atropos* is the same as that of *Trogium* (see under that genus) and the former generic name falls as a synonym.

Genus **Troctes** Burmeister, 1839

1758 (p. 610), Linnaeus described *Termes pulsatorium* and *Termes fatidicum.*

1776 (p. 184), Müller described *Termes divinatorium.*

1798 (p. 500), Illiger proposed the genus *Trogium* with one included species, *Hemerobius pulsatorius* F.

1839 (pp. 773–775), Burmeister proposed the genus *Troctes* with two included species, *Termes pulsatorium* L. and *Termes fatidicum* L.

1840 (Syn., p. 47; text, pp. 19–20, fig. 59: 13, 16–18), Westwood proposed the genus *Lachesilla* with genotype and only species *Termes fatidicum* L.

1866 (p. 220), Hagen listed both *pulsatorius* Burm. and *fatidicus* Burm. as synonyms of *divinatorius* Müll.

1880a (pp. 132–134), Kolbe discussed *Troctes divinatorius* and listed both *pulsatorius* and *fatidicus* of Burmeister as synonyms. The present writer has found no genotype designation in Kolbe's paper.

1905 (pp. 36–38), Enderlein selected *divinatorius* Müll., with *fatidicus* Burm. a synonym, as type of *Troctes* Burm. Enderlein considered that Burmeister applied the name *fatidicus* L. to specimens of *divinatorius* Müll. He accepted Burmeister's identification of *pulsatorius* L. as correct.

1911a (pp. 353–354), Enderlein said (apparently incorrectly) that Kolbe, 1880a, designated *divinatorius* as type of *Troctes.*

Conclusion.—No valid genotype of *Troctes* Burmeister, 1839, appears to have been yet designated, and the present writer hereby selects *Termes pulsatorium* L., 1758, as genotype. *Troctes* then falls as a synonym of *Trogium* Illiger, 1798, because of identical genotypes.

Discussion.—Some workers may feel that Westwood (1840) fixed the genotype of *Troctes,* by elimination, as *pulsatorius* L. This interpretation, if correct, would effect the same result as above, but the interpretation appears questionable. Opinion 6 of the International Commission on Zoological Nomenclature says, "When a later author divides the genus A, species Ab and Ac, leaving A, only species Ab, and genus C, monotypic with species Cc, the second author is to be construed as having fixed the type of genus A." For the present case to be entirely comparable to the hypothetical case of Opinion 6, Westwood should have indicated that he knew of the description of the genus *Troctes.* Because of this departure from the hypothetical case, and the fact that the Commission has three times rejected a proposal to raise type designation by "Elimination" (Article 30k) (see Stiles, 1929) from the status of a *recommendation* to that of a *rule,* the writer does not consider that Westwood fixed a type of *Troctes.*

The designation of *divinatorius* Müll. as genotype of *Troctes* by Enderlein (1905) is not acceptable because *divinatorius* was not one of the originally included species (see Article 30e). Had Enderlein listed *fatidicus* L., 1758, instead of *fatidicus* Burm., 1839, as a synonym the case might be altered, but it is evident that Enderlein included in the synonymy only Burmeister's misidentification of *fatidicus* L.

The writer's selection of *pulsatorius* L. as genotype may meet with objection on the ground that Burmeister misidentified the material referred to *pulsatorius.* Burmeister states, under *pulsatorius,* "Man findet Individuen mit sehr dicken Hinterschenkeln, welche gut springen, und andere ohne so starke Schenkel . . . ," and later, under *fatidicus,* "Bei den von mir untersuchten Individuen mit verdickten Hinterschenkeln waren die Augen schwarz, daher die Definition von *T. fatidicus* besser auf diese passen wurde." From these statements it appears that Burmeister considered the thick-legged individuals with black eyes (which probably were *divinatorius*) to represent *fatidicus,* and the remaining individuals were assigned to *pulsatorius.* Opinion 65 of the International Commission on Zoological Nomenclature states, "If an author designates a certain species as genotype, it is to be assumed that his determination of the species is correct; if a case presents itself in which it appears that an author based his genus upon certain definite specimens, rather than upon a species, it would be well to submit the case, with full details, to the Commission. At the present moment, it is difficult to lay down a general rule." Burmeister's case is not entirely comparable to the one represented by Opinion 65, since he did not designate a genotype, but the writer infers that misidentifications cannot be assumed unless there is strong evidence of a name having been based upon wrongly identified specimens. In the present case, there is no proof that true *pulsatorius* L. was not included in the series assigned to that name by Burmeister, and specimens of *divinatorius* apparently were referred to *fatidicus.* The bibliographic reference to "*Termes puls.* Linn. Fn. suec. 1937" is the first citation listed and the writer considers Burmeister to have made *pulsatorius* available for genotype designation.

Genus **Lachesilla** Westwood, 1840

1758 (p. 610), Linnaeus described *Termes fatidicum.*

1840 (Syn., p. 47; text, pp. 19–20, fig. 59: 13, 16–18), Westwood proposed the genus *Lachesilla* with genotype *T. fatidicum* L. by monotypy.

1866 (p. 202), Hagen suggested that Linnaeus's descriptive expression "Simile praecedenti, sed duplo majus," when comparing *fatidicum* to *pulsatorium,* was in error and that *fatidicum* L. really represented *divinatorium* Müller, 1776.

1867 (p. 196), McLachlan stated that he believed Westwood's specimens were a form of *Lachesilla pedicularius.*

1880a (pp. 118–120), Kolbe proposed the subgenus *Pterodela,* including *Hemerobius pedicularius* L. and *Caecilius quercus,* n. sp.

1883 (p. 315), Hagen referred *fatidicum* L. to the genus *Hyperetes.*

1884 (pp. 84–87), Kolbe doubted that *fatidicum* L. belonged to *Hyperetes* and emphasized the fact that he had immature specimens of *Pterodela* (equivalent of *Lachesilla*), which fitted the original description of *fatidicum* and which were found between dried plants, the source of Linnaeus's material.

1933 (p. 81), Pearman stated that he preferred to use the generic name *Pterodela* Kolbe, "since Westwood's generic diagnosis is erroneous and misleading, and his type specimens are in part defective and in part aberrant."

1935 (p. 106) Badonnel discussed the biology of *Lachesilla pedicularia* (L.), and mentioned the variety *fatidica* L. of which the female is totally apterous.

Conclusion.—*Lachesilla* is a valid genus, with *Termes fatidicum* Linnaeus its type.

Discussion.—That Linnaeus's expression, "Simile praecedenti, sed duplo majus" was not an error is indicated by its repetition (Linnaeus, 1761, p. 475) and by reference to the figures of Frisch (1734, Tom. 11, Tab. 10) cited by Linnaeus. The latter figures are not characteristic of *divinatorius.* Though Frisch's work is pre-Linnaean, it is of value in giving an understanding of Linnaeus's concept of the species. The fact remains that Westwood named his genotype which has been associated with the original Linnaean species; for this reason *Lachesilla* is valid. *Pterodela* Kolbe (genotype, *Hemerobius pedicularius* L.) is a synonym of *Lachesilla* (genotype, *Termes fatidicum* L.) because the genotypes are conspecific.

Genus **Clothilla** Westwood, 1841

1798 (p. 500), Illiger proposed the genus *Trogium* with one included species, *Hemerobius pulsatorius* F.

1841 (p. 480), Westwood described a new genus and species, *Clothilla studiosa,* without literature citations or references to other species.

1865 (p. 122, 124), Hagen examined the type of *studiosa* and indicated its identity with "the true *Termes pulsatorium* of Linnaeus, and *T. lignorum* of DeGeer."

Conclusion.—*Clothilla* is a synonym of *Trogium,* through synonymy of the genotypes.

Genus **Liposcelis** Motschulsky, 1853

1776 (p. 184), Müller described *Termes divinatorium.*

1853 (pp. 19–20), Motschulsky described *Liposcelis brunneus* in such a way that it is clearly congeneric with *divinatorium* Müller. Motschulsky also proposed the name *Liposcelis museorum* for a species to which he referred only as follows: "N'ayant pu trouver le nom et la description du soit-disant Psoque des boites à insectes, je crois pouvoir le signaler sous celui de *Liposcelis museorum,* vû que ce n'est pas dutout un Psoque."

1905 (p. 38), Enderlein listed both *brunneus* and *museorum* as synonyms of *Troctes divinatorius* (Müll.).

1911a (p. 353), Enderlein listed *museorum* as a synonym of *divinatorius* and indicated *museorum* as type of *Liposcelis,* with the result that *divinatorius* was considered the type by him. The species *brunneus* was considered valid, with *silvarum* Kolbe, 1888, a synonym.

1927 (p. 12), Enderlein treated *silvarum* as a valid species, without mention of *brunneus.*

Conclusion.—The species *museorum* was not sufficiently characterized by Motschulsky to constitute description, and *brunneus* is genotype of *Liposcelis.* The identity of *brunneus* is uncertain, but it is congeneric with *divinatorius,* so that *divinatorius* may be properly included in the genus *Liposcelis.*

NOMENCLATURE OF HIGHER CATEGORIES

For some time the family name Atropidae has been in rather general use. Since *Atropos* is invalid, the name must be changed. Trogiidae is available, and, following Enderlein (1919, p. 30), it is now being adopted.

During recent years many workers have used Psocoptera or Copeognatha as the ordinal name of the psocids, rather than Corrodentia. Corrodentia was used by Burmeister (1838, 1839) as a tribal name including termites, embiids, coniopterygids, and psocids. Brauer (1885), in proposing the classification that is generally accepted as the forerunner of all modern systems, used Corrodentia as an order for termites, psocids, and biting lice. In 1895 Comstock and Comstock restricted the order Corrodentia to psocids alone. Enderlein (1903b) proposed the name Copeognatha, and Shipley (1904) proposed Psocoptera for the psocids. The latter suggested that the suffix "ptera" be added to each ordinal name not already bearing it for the sake of uniformity. The ordinal names which he proposed for apterygotan orders and wingless pterygotan orders have not been generally accepted, but Psocoptera, Embioptera, and Ephemeroptera have met with considerable acceptance. Paraneuroptera, for Odonata, has not appeared in general use.

Imms (1924) and Wilson and Doner (1937) have reviewed the different ordinal classifications used by various writers. Chapman (1930), Comstock (1930), Handlirsch (1930), and Brues and Melander (1932) are among those using Corrodentia in the ordinal sense. On the basis of priority this is preferred to either Copeognatha or Psocoptera. Inasmuch as Shipley's system has not been followed in entirety, it does not seem important to use Psocoptera for the sake of uniformity. It may be argued that the names rejected, except for Odonata, are those of wingless orders, so that "ptera" does not properly apply to them. However, Odonata is still in general use, and, as Mickel (1934) has shown, the name is based upon the toothed maxillae of dragonflies. The name Corrodentia is derived from a Latin name meaning "gnawing," which is characteristic of the often injurious feeding habits of psocids. Because of priority, general usage, and fitting derivation it seems best to retain Corrodentia in preference to other names.

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SCIENTIFIC NOTES AND NEWS

THIRTY-FIRST EDITION OF THE DIRECTORY OF THE ACADEMY

In accordance with a custom only occasionally broken, the Academy issued in September its biennial directory of affiliated societies and members, familiarly known as the Red Book. The editorial work and responsibility for this directory were borne by H. G. AVERS and NATHAN R. SMITH, who constituted the committee appointed for the purpose.

In addition to the subject matter that has come to be associated with this work, such as the calendar of meeting dates of the affiliated societies and the thumbnail sketches of their history, this directory contains three new features. Lest these departures from past practice escape attention they are noted here.

For the first time, or at least for the first time within recent years, the directory contains a table of contents. This table lists the affiliated societies in the order in which they entered the Academy. There are 19 of these societies, 8 of which have been affiliated with the Academy since its organization in 1898.

On page 17 the directory lists the honorary members and patrons. These are arranged alphabetically and not in the order of their election. These names appear also in their proper place in the text.

Following the regular directory of Academy members, and members of the affiliated societies, the editors have compiled and listed alphabetically those of our members who have died. This latter listing is limited to those who were members in good standing at the time of their death.

In compiling a work of this nature it would be miraculous if no errors crept in. Only one has thus far come to attention, which, for purposes of the record, should be corrected. Under the general heading of Standing Committees, there are listed erroneously as members of the Meetings Committee the following: J. E. MCMURTREY, JR., CURTIS P. CLAUSEN, W. D. LAMBERT, and FRANCIS M. DEFANDORF. These gentlemen are the members of a special committee of which W. T. SCHALLER is the chairman. The Meetings Committee is composed of FRANK M. SETZLER, chairman, and JAMES F. COUCH, JOHN E. GRAF, CLEMENT L. GARNER, and FRED L. MOHLER.

The members are asked to scan their copies and notify the corresponding secretary of corrections.

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This Journal, the official organ of the Washington Academy of Sciences, publishes: (1) short original papers, written or communicated by members of the Academy; (2) proceedings and programs of meetings of the Academy and affiliated societies; (3) notes of events connected with the scientific life of Washington. The Journal is issued monthly, on the fifteenth of each month. Volumes correspond to calendar years.

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JOURNAL
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BOTANY.—*Four southwestern subspecies of* Phlox.[1] EDGAR T. WHERRY, University of Pennsylvania.

Study of the Phloxes of Arizona in the preparation of a treatment of the genus in Dr. T. H. Kearney's forthcoming flora of that State has indicated the occurrence there of four plants that seem best regarded as subspecies but have never been assigned to that status. In the present note these are formally described and named.

Phlox diffusa Bentham[2]

This species has already been divided into two subspecies, *longistylis* Wherry[3] of British Columbia to northern Oregon, and *typica* Wherry[3] of southern Oregon to south-central California. A third subspecies has now been found to occur on mountains and plateaus of the Great Basin region and may be known as:

Phlox diffusa subcarinata Wherry, subsp. nov. Fig. 1

Clumps averaging 7 cm high, with the densely leafy shoots 4 cm long. Deep-green linear-subulate leaves averaging 10 mm long and 1.25 mm wide, surficially glabrous or sparse pubescent, basally ciliate. Cyme of 1 to 3 flowers on pedicels 1 (rarely 2 or 3) mm long. Sepals averaging 9 mm long, united for one-half to two-thirds their length into a tube, with somewhat carinate intercostal membranes, sometimes glabrous but usually basally pubescent, often more densely so than in the other two subspecies. Corollas white to lavender, the tube averaging 11 and lobes 7 mm long. Styles 3 to 6 or rarely 7 mm long, united to within 1 mm of the tips.

P. diffusa typica similis sed compactior; calycis membranis intercostalis subcarinatis.

Type.—In herbarium of Academy of Natural Sciences of Philadelphia, from Mount Rose, Washoe County, Nev., *Heller* 9910a, July 29, 1909. A sketch of one of the plants on the type sheet is reproduced herewith.

Range.—Washington and Idaho to California and Arizona, chiefly at altitudes of 5,000 to 10,000 feet in the Great Basin, and rarely in the Sierras. Localities represented in the larger eastern herbaria:

WASHINTON: Mount Spokane (n. limit, lat. 47° 53′), Tumwater Mountain, Klickitat Hills.

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[1] Received August 28, 1939.
[2] Pl. Hartw.: 325. 1849.
[3] Proc. Acad. Nat. Sci. Philadelphia 90: 139. 1938.

Oregon: Maupin, Strawberry Lake, Crane Mountain.

Idaho: Brundage Mountain.

California: Bray, Mount Shasta, Truckee, Pine City, Mount Kaiser, Mineral King, Mount Pinos (s. limit, lat. 34° 48′).

Nevada: Mount Rose, Franktown, Carson City, Kings Canyon.

Utah: Virgin River Valley.

Arizona: Jacobs Lake and points southward, north rim of Grand Canyon.

Fig. 1.—*Phlox diffusa subcarinata* Wherry, subsp. nov. Drawn by Miss Inez Renninger.

Phlox austromontana Coville[4]

The acerose-leaved plant with markedly carinate calyx-membranes to which this name was originally applied has short-decumbent or erect stems forming a compact clump, its longest leaves 12 to 20 mm, its corolla-tube 8 to 14 mm, and its styles 2.5 to 5 mm in length. The subspecies represented may be known as *P. austromontana* **vera** Wherry, nomen novum.

A variant of the species with long-decumbent stems forming an open clump, longest leaves 15 to 30, corolla-tube 12 to 18 mm, and styles 4.5 to 6 mm in length has been named by E. Nelson[5] var. *prostrata.* Its differences from the original subspecies are so marked, however, that it is here raised to subspecies rank: *P. austromontana* **prostrata** (E. Nelson) Wherry, status novus.

In his monograph of the genus, Brand[6] segregated from *P. austromontana* a supposedly distinct species, which he named *P. densa.* He noted that this had the aspect of an alpine form of the earlier species but considered its longer style to be distinctive. Study of a series of specimens of both indicates

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[4] Contr. U. S. Nat. Herb. **4**: 151. 1893.

[5] Rev. W. N. Amer. Phlox: 19. 1899. Also named *Phlox acerba* by A. Nelson, Amer. Journ. Bot. **25**: 114. 1938.

[6] Engl. Pflanzenr. **IV. 250**: 83. 1907.

that no correlation exists between style-length and any other character, and as extensive intergradation is shown the two can scarcely be maintained as independent. The plant with especially compact habit, longest leaves 8 to 12 mm, corolla-tube 8 to 14 mm, and styles 3 to 6 mm in length is therefore here made a subspecies: *P. austromontana* **densa** (Brand) Wherry, status novus.

All three of these subspecies were first described from southwestern Utah; subsp. *vera* is now known to occur in all the Western States south of lat. 45°. Subsp. *prostrata* extends to southern California, where it is especially frequent, and to southeastern Arizona. Subsp. *densa* apparently occurs only from west-central Utah to middle Arizona.

ZOOLOGY.—*Observations on the distribution and ecology of the oribatid mites.*[1] WENDELL H. KRULL, U. S. Bureau of Animal Industry.

The oribatid mites have been incriminated only recently as intermediate hosts of economically important tapeworms of livestock. Stunkard (1937) reported recovering from experimentally infected mites, *Galumna* sp., cysticercoids of the common sheep tapeworm, *Moniezia expansa.* Later Stunkard (1939) reported in detail the experiments leading to this discovery and noted that "all the mites used fall within the generic concept of *Galumna.*" He did not, however, identify definitely the infected mites as to species. Stunkard's work has subsequently been confirmed by Stoll (1938) and by the writer (Krull, 1939). Stoll reported infecting two kinds of mites, *Galumna* sp. and *Galumna nigra* (Ewing), by feeding to these arthropods eggs of *Moniezia expansa,* while the writer recovered infective cysticercoids of this tapeworm from mites, *G. emarginata* (Banks), which had been collected on pastures. The cysticercoids collected by the writer were administered to a tapeworm-free lamb, and specimens of *M. expansa* were recovered from this host animal at necropsy.

Although extensive studies on the oribatid mites have been published by Michael (1884, 1898), Banks (1915), Ewing (1917), and Jacot (1937), very little is known of their distribution and ecology. In order to obtain information on these points, which is needed before control measures for the anoplocephaline tapeworms of livestock can be formulated, a preliminary investigation was undertaken to determine under what conditions these mites occur, and the influence of climatic and other factors on their distribution and abundance. The results of this investigation are given herein. Some preliminary observations on the food habits of these mites and attempts to culture them are also included.

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[1] Received June 27, 1939.

METHOD OF COLLECTING ORIBATID MITES

Conventional methods of collecting free-living mites were of limited value because in this study mites were required in large numbers, and from grass collected under all weather conditions, therefore, the following method was devised: Grass from which oribatid mites were to be collected was cut with ordinary grass shears and transferred in buckets to the laboratory. The grass was then washed immediately by transferring it, not over one pound at a time, to a parallel-sided glass jar, having a capacity of about 14 liters. The jar was filled to within several inches of the top with tap water having a temperature of not more than 60° F. The grass was plunged up and down several times in the water, then removed, a small amount at a time, after it had been agitated again in the water to remove any mites that might have remained attached. When all the grass had been removed, the washings were poured into a similar container through a screen having 34 meshes to the linear inch. The jar in which the grass had been washed was rinsed with water of the same temperature at least once and the washings poured through the screen, care being taken to cover most of the screen surface in order to remove any remaining mites. While the contents of the jar settled, the surface was examined for mites and any that appeared there were removed. After 2 or 3 minutes the water, except for 1 to 2 liters, was very carefully and quickly decanted. The remaining portion with the sediment was agitated and transferred to a 4-liter battery jar. The larger jar was rinsed with enough cold water to fill completely the smaller jar to within about an inch of the top. During sedimentation the surface of the water was examined again for mites, and any that were present were removed. As soon as the solid contents had settled the water was carefully and quickly decanted, leaving in the jar about 150 cc, which, after being agitated, was transferred to a 250-cc cone-shaped graduate, filling it to near the top. After the contents had settled and any mites coming to the surface had been removed, about 200 cc of the water was very carefully decanted and replaced by water having a temperature of 113° F. The addition of warm water changed the density of the medium and forced the mites to the surface and through the film formed by the surface tension so that they could be removed. For this procedure two teasing needles were held crossed and close together near the mites. When the needles were raised slowly the mite or mites adhered to one of the two needles. By touching the needle with the mite to a drop of water in the center of a watchglass the mite was released and would slide down the film formed by the surface tension to the edge of the drop, where it became imprisoned. When all the mites had been transferred to the drop and while under observation through a binocular microscope they were drawn to one side and out of the drop with a teasing needle. The drop of water was then removed with a pipette. As soon as the water around the mites dried, one part of a gelatin capsule was slipped over them and while this was held in place the dish was inverted to transfer the mites; the remaining part of the capsule was then replaced. The mites were retained in the closed capsule until needed.

Though this method may appear somewhat unwieldy and unpractical, it will be found after a little practice to be quite efficient. However, certain details must be observed in order to obtain satisfactory results. In collecting the grass care must be taken to prevent loss of mites through undue disturbance, especially when the grass is dry. It is best to carry the washing process to its completion in the least possible time to prevent loss of mites. When the washings are sedimenting in the larger jar immediately after being screened, it is only rarely that a mite will be found on the surface. However, while the material is in the smaller jar a few of the mites may come to the surface, and these should be removed immediately. The number of mites coming to the surface in the smaller jar is usually an index to the final count, since 3 to 5 percent of the mites for each pound of grass seem to appear on the surface at this time. A few mites may be found on the surface of the cold water in the small graduate, but the limited surface makes it easy to remove them quickly. When the water at higher temperature is added, the majority of mites come to the surface; this has been verified by examination of the debris. To make sure that the mites were not imprisoned in the debris, the contents of the cone were agitated several times with a steel knitting needle.

Oribatid mites on the surface of the water are very distinctive in appearance and resemble tiny black or brown glistening pearls. It is only rarely that enough debris, including various organisms, comes to the surface to interfere seriously with the removal of the mites; should this happen, jarring the container or agitating the surface slightly with a needle will cause the debris to sink.

The heat of the water does not destroy the mites, although sometimes it seems to reduce their vitality. If it is desired to keep the mites alive for some time, the hot water should be omitted, leaving the cold water in the graduate. As the water temperature increases, the mites rise slowly and continue to rise for periods up to 3 hours.

Any attempt to shorten the process by omitting the second or battery-jar stage of washing, which involves decanting enough water from the large container to transfer the remaining contents directly to the small graduate, will lead to unsatisfactory results.

In order to obtain the maximum number of mites from grass from a given area, the samples should be collected in the morning following a rain sufficient to saturate the ground. The grass at the time collected should be only slightly moist, the day cloudy, and the collection made as soon after daylight as possible. When the number of mites per pound of grass is large, it is well to wash the grass a second time in order to obtain the maximum number present.

OBSERVATIONS ON THE ECOLOGY OF ORIBATID MITES

The data so far obtained are based on the study of mites from October 18, 1937, to May 27, 1938. The conclusions relative to abundance, distribution, and conditions affecting the mites were reached from a study of the mites collected from 359 samples representing a total of 618 pounds of grass. The samples varied in weight from 1 ounce to 3 pounds, with an occasional larger sample; these samples were collected from 12 stations at the Agricultural Research Center, Beltsville, Md. A total of 18,238 oribatid mites were recovered from the grass collected and examined; this represented an average of about 30 mites per pound of grass.

The following species of mites[2] were collected: *Dameosoma minuta* Ewing, *Galumna curva* (Ewing), *G. emarginata* (Banks), *G. minuta* (Ewing), *G. rugosala* (Ewing), *Notaspis spinipes* (Banks), *Oribatula minuta* (Ewing), *Oripoda elongata* Banks and Perg., *Phthiracarus americanus* Ewing, *Zygaribatula clavata* (Ewing), unidentified species of *Ceratozetes, Fuscozetes, Galumna, Liebstadia, Neoribates, Oribatella, Pelops, Scheloribates, Sphaerobates,* and *Zygaribatula,* and new species in at least two new genera. The species collected from an old, permanent, open sheep pasture were *Galumna emarginata* (Banks), *G. minuta* Ewing, *Galumna* sp., *Oribatula minuta* (Ewing), *Oribatula* sp., *Pelops* sp., *Scheloribates* sp., and *Sphaerobates* sp.

Factors affecting distribution of oribatid mites.—The mites in the area studied were rather general in distribution, and an occasional one could be found almost anywhere, even in areas that were quite barren. In certain grassy areas, however, which, judged from all known data concerning their habitat, should have had mites in

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[2] The identifications were made by Dr. H. E. Ewing, of the U. S. Bureau of Entomology and Plant Quarantine.

abundance, these arthropods were found only with difficulty. The mites were more apt to be found in abundance and retained the greatest constancy in areas where moisture was plentiful enough to prevent limitation of the growth of grass.

The mites were found in considerable numbers under almost any pasture condition. In open pastures having only occasional deciduous trees, the shaded areas did not influence to any extent the distribution of the mites, except that during the winter months a few more mites were always collected from around the isolated trees. The mites were much more apt to be abundant in pastures shaded by coniferous trees, where the organisms were protected throughout the year from the effects of sudden and excessive changes of environmental conditions. In the area studied the mites were most abundant in a heavily shaded flat pasture surrounded by coniferous and deciduous trees and containing grass of a soft texture and about 6 inches high. The mites were not reduced excessively by prolonged cold wet weather of a week's duration or by a prolonged dry spell of a month, if these changes occurred during spring and early summer.

The relative number of mites found on the grass in a given location varied tremendously with conditions of environment, the influence of some factors having been ascertained. Those factors that have been more or less definitely established as influencing the vertical distribution of the mites are water, light, wind, and food.

The mites seem to have a very delicate adjustment to water, and succumb readily at room temperature if they are not protected from evaporation; they may be floated on water, without taking food, for at least 18 hours. In their native habitat the mites apparently maintain their relationship to proper moisture conditions by their movements in and on the ground and on the grass, and in this respect they have considerable latitude with regard to moisture, as well as to other conditions. The proportion of mites on the grass in a given area apparently depends to a large extent on moisture conditions. They were the most abundant the day after a heavy rain sufficient to saturate the ground thoroughly, and this was found to be the only time that an estimate could be obtained from grass samples of the number of mites in any location. Since the mites respond negatively to excessive moisture, it may be assumed that their presence in large numbers in the grass after heavy rains is an attempt on the part of the mite to escape this moisture. In accordance with this response it has been found that light rains, heavy fogs, and dew do not change materially the distribution of the mites, and of these conditions the light rains affect them most. Their response to snow was not studied, but it was possible always to collect them from grass covered with snow.

The mites avoid excessive light, and on clear days very few if any could be collected from grass; they were most abundant immediately after daybreak. On cloudy days they remained somewhat more numerous and constant throughout the day. They appear to leave the grass when there is a high wind. The number of mites on the grass increased immediately when a cloudy day with light rains succeeded a period of 2 or 3 days without rain.

Just what effect temperature has on the mites has not been definitely determined, but from the observations made it seems to have little or no effect. As previously mentioned, mites were collected from grass cut in snow; moreover, they were as abundant on grass at a temperature of 20° F., the lowest encountered during the period covered, as they were at higher temperatures.

Seasonal distribution.—The mites were found to be much more abundant in spring than in winter, and there is a very sudden and striking increase in numbers when the new spring growth of grass is about 3 inches tall. It is possible that a part of this increase in mites is the result of the accumulation of eggs and young during the winter months, when periods of warm weather are not of sufficient duration to allow the mites to mature but are long enough for the adults to feed and lay eggs. The relative number of mites present during fall and winter as compared with the number present in spring after the new growth of grass appears may be deduced roughly from the following data: From 406 pounds of grass collected from October 18 to March 17, a total of 4,898 mites were obtained, whereas 13,340 mites were recovered from 212 pounds collected from March 18 to May 27. From 226 pounds of grass collected in a sheep pasture from October 18 to March 17, 1,821 mites were recovered as compared with 59 pounds of grass collected in the same pasture from March 18 to May 27, which yielded 4,527 mites.

Prevalence of mites on grass.—On the basis of the data so far obtained, it appears that the actual number of mites on grass varies considerably, and that there are times, even in spring, when no mites can be recovered. The largest number of mites per pound of grass recovered from an open sheep pasture was 619; these were obtained from 15 ounces of grass taken on May 20. The largest number prior to the time of the spring growth of grass was 100 per pound, which were obtained from a 2½-pound sample collected on February 18.

The largest number per pound of grass was from samples taken from a shaded pasture, where 2,547 mites were obtained from 2 pounds of grass collected at 9 a. m. on May 19. From this same pasture 1,158 were taken from 1 pound 10 ounces of grass at 11 a. m. on March 31. Because of excessive grazing, not enough collections were made prior to the time that the spring growth appeared to give a comparison. In an area frequented by wild rabbits, on the edge of a pond, the largest number of mites per pound of grass was 325 from a 1 pound 4 ounce sample collected at 9 a. m. on March 18; the largest number prior to the spring growth of grass was 187 from 1 pound 4 ounces of grass taken on October 29.

Under ordinary dry conditions, beginning on the fourth day after a rain, it was unusual to find the mites in greater abundance than 5 per pound of grass after 9 a. m. The variation in the numbers of mites present in a given area on different, yet not widely separated, days is shown by the following data: From a collection of 1 pound 13 ounces of grass taken at 8 a. m. on May 16, 168 mites were obtained. In the same area a collection of 1 pound 4 ounces of grass taken at 9 a. m. on March 28 yielded 12 mites, whereas 1 pound 10 ounces of grass collected at 11 a. m. on March 31 yielded 1,158 mites.

Response to artificial change of conditions.—After the abundance and distribution of the mites in a pasture had been ascertained, certain selected portions were fenced. These areas were used for the purpose of encouraging the multiplication and growth of the mites. Pellets from two sheep contaminated with eggs of *Moniezia expansa* were spread on the areas during fall and winter months. This ground was never without water for more than 3 days; in the event that rain did not fall in the allotted time the ground was sprinkled. In the spring the excess debris was raked off and the areas were kept free from weeds. Grass samples from which the mites were collected were taken throughout the period of investigation, and during that time a few mites, rarely in excess of the general average, could always be collected. The record number per pound of grass, 115 mites, was taken from a 1 pound 10 ounce sample collected on April 15. The interesting fact about these areas was that the mites did not respond to this kind of treatment, as indicated by the small number collected from the grass samples. The reason for this indifferent response is not apparent.

After it had been determined that the maximum number of mites on grass could be collected after rains extensive enough to saturate the ground, it was assumed that the same results could be obtained by sprinkling areas and cutting the grass the following day. However, the results were not as anticipated. Usually the sprinkling increased slightly the number of mites on the grass, the maximum results achieved comparing favorably with those following light rains.

Relative abundance of species.—Beginning in March mites were separated into several distinguishable types, some of which represented distinct species; consequently, comparisons as to abundance and distribution can be given. The total number of mites collected and separated from all localities studied was 11,310, and of these 568 were *Galumna emarginata,* which had been determined by the writer (Krull, 1939) to be an intermediate host of the sheep tapeworm, *Moniezia expansa.*[3] The mite was found to be generally distributed, having been collected at all seasons studied; however, it was more variable as to relative numbers when compared to the rest of the mites. These mites were most abundant during April and May, and at this time more abundant in an open pasture than in one that was heavily shaded. In an open pasture in which there was a single deciduous tree, the mites were most numerous during fall and winter in the grass around the tree than in the rest of the pasture; in spring the conditions were reversed. During the winter months this mite was found to be commonest on an area near a pond where moisture conditions were the most constant of any area studied. In spring the mites were the most numerous in an open, low-lying, flat, undergrazed pasture in which the grass was rather high. *Galumna emarginata* was rarely more abundant than 5 per pound of grass at any time or in any plot, although in one exceptional case 89 were taken from 15 ounces of grass collected on May 20 from the low-lying pasture.

Galumna minuta was the commonest mite found, and of the 11,310 mites already mentioned 7,270 were of this species. This species was generally distributed and was collected from all stations in all seasons studied.

Nymphs of oribatid mites could be found at all seasons but were commonest during the last week in March and during the last week in May.

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[3] During April and May, 286 specimens of *Galumna emarginata* collected from pastures contaminated with eggs of *M. expansa* were dissected and examined for larval tapeworms. Five were found to be infested, each containing one fully developed cysticercoid; one of the mites had, in addition, two undeveloped cysticercoids that had attained nearly maximum size. One other mite collected in November contained a fully developed larva. Four of the 5 cysticercoids were measured without pressure in water and averaged 178μ long by 147μ wide, the largest being 200μ by 150μ and the smallest 160μ by 145μ. During the same months 2,606 specimens of *G. minuta* were examined for cysticercoids and all were negative. Of the other species of oribatid mites, 623 were examined and all were negative.

OBSERVATIONS ON THE FOOD HABITS OF ORIBATID MITES

The oribatid mites in general eat hyphae and spores of fungi, debris, anoplocephaline tapeworm eggs, and cellular material of blades of dead grass in certain stages of decomposition. They exhibit considerable choice as to the fungi they eat, devouring only certain of the white fungi and their black spores, ignoring completely any in which the hyphae are colored. The fungi are eaten in a moist or dry state. The mites have gluttonous appetites and devour an enormous amount of material. In feeding them eggs of the tapeworm *M. expansa*, it was found the debris surrounding the eggs as well as the eggs was desired as food. Eggs that were moist were not accessible to the mites and were merely pushed around by them. Eggs that were accessible had to be well anchored and apparently dry. Since the mouth parts of the mites are such as to prevent the ingestion of the egg in its entirety, the mites gain entrance to the eggs by making a hole in the outer dry membranes and ingest the contents which are freed in this manner. The remaining parts of the membranes are usually ignored. Mites have been observed to work for considerable periods of time before succeeding in making an opening in an egg. The observations concerning the reactions of the mites to tapeworm eggs may be easily demonstrated by applying eggs to pieces of agar dispersions which are dried and placed in a container where the mites have access to them.

CULTURING ORIBATID MITES

Attempts were made to culture the various oribatid mites in covered stender dishes of several sizes and in various larger containers. For substratum substances soil, sand, paper, filter paper, and agar dispersions have been used, and pebbles, grass leaves, decaying plant material, and pieces of agar and paper have been employed to give them retreats and cover. Fungi in addition to those transferred accidentally to the habitat were supplied on pieces of grass leaves and pieces of agar. Numerous mites have been raised in this way, but no method has been found that could be depended on to give consistent results. The number of nymphs sometimes appearing in an experimental habitat was exceedingly large in view of the number of adults supplied for stock and the small number of eggs carried by the mites at one time.

The individual species varied considerably in their response to artificial culture. Species of the genus *Galumna* were the most difficult to handle. *G. minuta* was raised to maturity in several cultures. *G. emarginata* although the largest and most robust mite encountered was the most difficult to handle and could be kept at most only a couple of weeks. Nymphs of *G. emarginata* hatched under artificial conditions lived only a few days.

SUMMARY

A method for collecting oribatid mites under all weather conditions has been described.

Oribatid mites in the region studied were most abundant on grass after rains sufficient to saturate the ground, and they retained their greatest constancy in areas where moisture was plentiful enough to prevent limitation of the growth of grass. Numerous mites of the various species recorded could be collected from sheep pastures. Water, light, wind, and food are factors that were found to be important in influencing the vertical distribution of the mites on grass. A striking increase in the number of mites on grass was observed at the time the spring growth of grass was 3 inches tall. Mites kept under controlled conditions ate hyphae and spores of fungi, debris, cellular material of blades of dead grass, and anoplocephaline tapeworm eggs.

Numerous mites of the various species recorded were dissected and examined for cysticercoids of *Moniezia expansa,* which were found only in *Galumna emarginata.* This mite was generally distributed, could be collected at all seasons during which the investigation was in progress, and was taken only rarely in greater numbers than 5 per pound of grass.

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ENTOMOLOGY.—*Revision of the genus* Ceratagallia *Kirkaldy (Homoptera: Cicadellidae).*[1]

P. W. Oman, U. S. Bureau of Entomology and Plant Quarantine.

The monobasic genus *Ceratagallia* was established by Kirkaldy[2] for *Agallia bigeloviae* Baker. Because the name was published without a formal description, subsequent authors have considered it a *nomen nudum.* However, the inclusion of the previously described species, *bigeloviae* Baker, satisfies the requirements of the International Rules of Zoological Nomenclature, and *Ceratagallia* is available for the species treated in this paper. Attention is called to the fact that *Ceratagallia* Kirkaldy is an older name than *Aceratagallia* Kirkaldy,[3] although the latter name appeared in Bulletin 3 and the former in Bulletin 4.

Ceratagallia and *Aceratagallia* may be distinguished from other North American agallian leafhoppers by the character of the pronotum, which is transversely striated, and the styles of the male genitalia, which are not forked. In addition, the nymphs are without cephalic processes. *Ceratagallia* is differentiated from *Aceratagallia* by the 4-lobed posterior margin of the seventh sternite of the female and the V-shaped aedeagus of the male. The males may usually be recognized also by the shape of the plates, which are usually about 2 to 2½ times as long as their combined basal width and have the lateral and distal margins turned strongly upward, thus forming a trough-shaped cavity in which lie the distal extremities of the styles. Representatives of typical *Aceratagallia* are widely distributed in the Nearctic region, whereas the species of *Ceratagallia* are confined to the semiarid portions of the United States and adjacent Mexico. Representatives of the latter genus are at hand from Lower California, California, Arizona, Nevada, Utah, Idaho, Colorado, New Mexico, Texas, and Kansas.

Ceratagallia includes the species treated by the writer[4] in 1933 as the *bigeloviae* group of the genus *Aceratagallia.* At the time those studies were made, relatively little material belonging to this group was available. The accumulation of additional material, especially from California, has brought to light a number of new species, as well as specimens which alter somewhat the specific concepts established in the previous work. It seems desirable, therefore, to review the group again in order to incorporate the new species into the scheme

[1] Received June 15, 1939.

[2] Hawaiian Sugar Planters' Assoc. Expt. Sta., Div. Ent. Bull. **4**: 61. May 1907.

[3] Hawaiian Sugar Planters' Assoc. Expt. Sta., Div. Ent. Bull. **3**: 11, 30. Sept. 1907.

[4] U. S. Dept. Agr. Tech. Bull. **372**: 46.

of classification, and to make such changes as are necessary in the interpretation of the previously described forms.

In order to avoid repetition in the specific descriptions that follow, a résumé of certain general characters is given at this point. The bases for the differentiation of *Ceratagallia* from other agallian leafhoppers have already been given. Thus defined, the genus constitutes a remarkably homogeneous group. The species are all rather robust, the slenderest being *lobata* (Oman), which resembles closely *Aceratagallia gillettei* (O. & B.) in general appearance. An accurate idea of the general habitus of the species may be gained by examination of Figures G, H, and I of Plate 2 of the writer's 1933 paper. Although color markings may be either present or absent, and vary from fuscous to brown within a species, when present they form a pattern that is very uniform throughout the genus. In the approximate order of their frequency of appearance in the adults, the color markings are as follows: A pair of round or ovate spots on the crown above the ocelli; a pair of triangular marks at the base of the scutellum; the veins of the corium, with the exception of the base of R+M, which is white, and the base of Cu_1, which is usually sordid yellowish white; a pair of slender stripes along the commissural line in the outer cells of the clavus, these usually fused with fainter markings which occur in the cells of the clavus and parallel the claval veins; irregular and frequently interrupted stripes along the claval suture, and indefinite elongate marks in the cells of the clavus and corium adjacent to the claval suture basally; a pair of narrow stripes along the median line, extending across the pronotum and crown, and fusing, on the face, with the stripes along the base of the clypeus; an interrupted arc on each side of the pronotum basally, this frequently connected with the median stripes, and usually connected with a broad inner vitta and a narrow outer vitta extending from the arc to the posterior margin of the pronotum; an irregular mark in each ocellocular area, with an extension toward the adjacent ocellus and one along the antennal pit; the facial sutures, antennal pits, and transverse bars on the clypeus laterally; the transverse suture of the scutellum, and a pair of small spots just anterior to it; various indefinite areas, which tend to be darker on the dorsum of the abdomen, the distal portions of the female pygofer and ovipositor sheath, the median line of the male plates, and the lateral portions of the sternites.

The nymphs normally have the spots on the crown reduced to oblique dashes. The paired median dorsal stripes are broader than in the adult and continue to the apex of the abdomen, while the lateral portions of the dorsum are occupied with more or less continuous longitudinal marks which serve to accentuate the unmarked yellowish portion of the dorsum laterad of the median stripes. Other markings on the nymphs are somewhat similar to those of the adults, although the nymphs are more frequently entirely without markings.

Of the various structures of the internal male genitalia, that portion of the style caudad of its point of attachment to the genital capsule seems to be the only part furnishing characters reliable for specific differentiation. This part of the style is frequently boot-shaped in outline, and consists of a relatively slender basal portion, the shank, an expanded distal portion which is usually foot-shaped and hence conveniently termed the "foot" of the style, and usually a ventral projection called the ventral tooth. Of the parts of the foot of the style, the "heel" is formed by the angle adjacent to the serrated margin of the shank, and is usually distinctly less produced than the "toe." Although subject to some variation, the gross outline of the style is usually sufficiently characteristic to permit specific identification from this structure alone. The number and arrangement of the setae on the style and the minute details of the serrations on the inner margin are only helpful in a general way, but in the accompanying drawings they have been portrayed as accurately as possible for the sake of completeness.

The diagnostic characters of the styles of the males are most conveniently studied and illustrated if removed from the genital capsule. Consequently, in this study, following the customary treatment with caustic potash, the styles, connective, and aedeagus have been carefully dissected out and mounted in balsam on microscope slides. The cover glass should be pressed down sufficiently to orient the broadened distal portion of the style in a horizontal plane. These structures are best studied with a compound microscope at magnifications of from 60 to 120 diameters, although less magnification is satisfactory for most purposes.

The illustrations accompanying this paper were made on coordinate paper with the aid of a micrometer scale placed in the ocular of a compound microscope. All drawings show the outline of the distal portion of the right style in dorsal view, and since they are drawn to the same scale they give an accurate idea of the relative size of these structures in the various species.

CONCERNING A KEY

With the exception of the characters presented by the styles of the internal male genitalia, the differences between the various species of this group are usually such that they do not lend themselves well to use in a key. It seems impossible to indicate reasonably positive characters for the separation of the species without relying almost entirely upon the characters of the styles, and there seems no point in presenting a key when equally satisfactory results may be obtained, probably more efficiently, by comparing these structures with the accompanying illustrations. In the absence of a key it is perhaps well to indicate that the most reliable external characters are the size, relative robustness, and presence or absence of markings. Of the internal characters, the general outline of the foot of the style, the size and position of the ventral tooth, and the width and curvature of the shank have proven most useful in differentiating closely related species.

Ceratagallia lobata (Oman), n. comb. Fig. 1

Aceratagallia lobata Oman, U. S. Dept. Agr. Tech. Bull. **372**: 67. 1933.

A relatively slender, dark-colored species. Heel and toe of style of approximately equal size; style obliquely subtruncate distally. Length 2.8–3 mm.

External characters.—General ground color sordid cinereous; markings of brown and fuscous sufficiently extensive to give the entire insect a fuscous appearance. Male plates rather short, tapering slightly from base to apex.

Internal male genitalia.—Shank of style short and comparatively broad. Ventral tooth small and situated at about narrowest part of shank. Posterior margin of style slightly sinuate; inner margin distally finely serrate. Distal part of aedeagus flattened dorsoventrally, apex sagittate in outline.

Localities.—Type locality, Glendale, Nev. Type, U.S.N.M. no. 44650. Other material from the following localities examined. ARIZONA: Ashfork, Oak Creek Canyon, Prescott, Sacaton, Santa Rita Mountains, Yarnell Heights, and Yavapai County. CALIFORNIA: Alpine, Big Bear Lake, Mint Canyon, and San Jacinto Mountains. NEVADA: Glendale, Las Vegas, and Mesquite. UTAH: St. George.

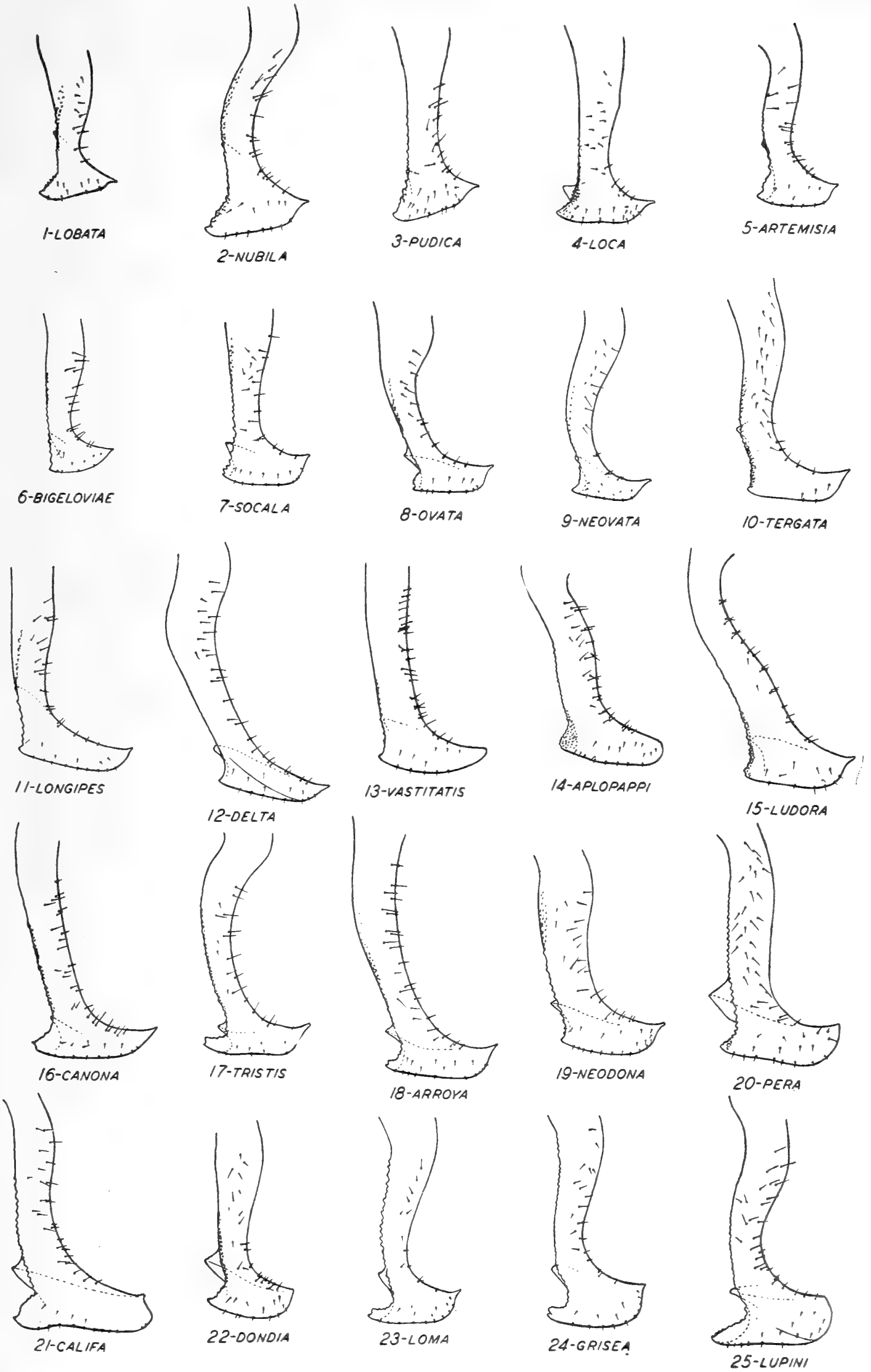
Host.—Unknown.

Ceratagallia nubila, n. sp. Fig. 2

Resembling dark specimens of *dondia* in general appearance, but with the male plates broader distally and the styles more like those of *lobata*, with the heel and toe of nearly equal size. Length 3.25–3.5 mm.

External characters.—General ground color sordid yellowish white; brown and fuscous markings much more clearly delimited than in *lobata*. Male plates long and nearly parallel margined, proportionally wider than those of *lobata*.

Internal male genitalia.—Shank of style slender, rather long, and distinctly sinuate. Ventral tooth very small, and located as in *lobata*. Posterior margin of style obliquely subtruncate, inner margin distally finely serrate. Aedeagus with a blunt tooth on dorsal margin just before apex.



Figs. 1–25.—Leafhoppers of the genus *Ceratagallia* Kirkaldy: Dorsal views of distal portion of right style.

Locality.—Type locality, Wickenburg, Ariz. Holotype male, allotype female, and 2 male and 1 female paratypes taken August 20, 1938, and 2 male paratypes taken June 16, 1937, all collected by D. J. and J. N. Knull. Holotype, allotype, and 2 paratypes in collection of Ohio State University; 3 paratypes in U. S. National Museum, no. 53350.

Host.—Unknown.

Ceratagallia pudica, n. sp. Fig. 3

More robust than *nubila* and without extensive fuscous markings. Style resembling that of *lobata* but with a relatively more slender shank and a less produced heel. Length 2.8–3.2 mm.

External characters.—General ground color sordid yellowish white; markings mostly pale yellowish brown or brown. Head tumid, distinctly longer medially than next the eye. Male plates rather short and broad, tapering slightly from base to apex. Median lobes of seventh sternite of female much shorter than lateral lobes.

Internal male genitalia.—Shank of style nearly straight. Ventral tooth small and situated nearer apex than in *lobata.* Heel distinctly shorter than toe. Posterior margin of style obliquely subtruncate; inner margin finely serrate distally. Apex of aedeagus recurved, forming a slight hook.

Localities.—Type locality, Tucson, Ariz. Holotype male, allotype female, and 1 female paratype collected June 18, 1933, P. W. Oman, U.S.N.M. no. 53351. Also 2 male paratypes from Hualpai Mountain, Ariz., July 4, 1937, and August 6, 1938, D. J. and J. N. Knull, in Ohio State University collection.

Host.—Unknown.

Ceratagallia loca, n. sp. Fig. 4

A robust species, resembling *pudica* in form but with a less tumid head and fewer markings. Apex of style not obliquely subtruncate. Length 2.8 mm.

External characters.—General color pale sordid yellow; markings very pale or absent except for fuscous veins of corium, ovate fuscous spots on crown, and traces of arcs on anterior margin of pronotum. Male plates short, tapering slightly from base to apex. Median lobes of seventh sternite of female divergent, rather sharply pointed, and with margins brown.

Internal male genitalia.—Shank of style relatively stout and straight. Ventral tooth large and pointed, situated just basad of apex of style. Posterior margin of style slightly sinuate and curving cephalad toward attenuate toe; heel short and stout; inner margin finely serrate. Apex of aedeagus recurved, forming a small hook.

Locality.—Type locality, Lancaster, Calif. Holotype male, allotype female, and 1 nymph, June 8, 1935, P. W. Oman, U.S.N.M. no. 53352.

Host.—Unknown.

Ceratagallia artemisia, n. sp. Fig. 5

Aceratagallia bigeloviae Oman (in part, not Baker), U. S. Dept. Agr. Tech. Bull. **372**, pl. 2, I. 1933.

Previously confused with *bigeloviae,* but with much darker markings and with the heel of style more produced. Length 2.5–2.7 mm.

External characters.—General color pale cinereous; markings of fuscous or brown mostly distinct and sharply delimited. Form very robust, head somewhat tumid. Male plates short and comparatively broad. Median lobes of seventh sternite of female nearly as long as lateral lobes, longer and more slender than those of *bigeloviae*.

Internal male genitalia.—Shank of style slightly sinuated and more slender than that of *bigeloviae*. Ventral tooth small and situated more basad than in *bigeloviae*. Posterior margin of style curving less gradually to apex of toe than in *bigeloviae;* heel, although variable in size, usually strongly produced; inner margin irregularly serrate distally. Apex of aedeagus distinctly hooked.

Note.—This is the species represented by Plate 2, I, of the writer's 1933 paper on the group. At that time only a few specimens were available, and they were believed to be dark-colored examples of *bigeloviae*.

Localities.—Type locality, Twin Falls, Idaho. Holotype male, allotype female, and 2 male and 8 female paratypes, May 6, 1937, J. A. Gillett. Also the following paratypes from Idaho. Hollister: 1 male and 1 female, August 27, 1928, D. E. Fox; 2 females, May 19, 1931, D. E. Fox; 1 male, July 24, 1931, D. E. Fox; 1 male, August 23, 1933, D. E. Fox. Wendell: 1 male, May 19, 1933; 2 females, June 9, 1933. Hagerman: 1 male, September 13, 1932. Berger: 1 female, May 20, 1937, J. A. Gillett. Castleford: 1 female, November 14, 1936. There are also at hand 2 males and 1 female from Salt Lake City, April 25, 1936, C. F. Smith. Types in U. S. National Museum, no. 53353, paratypes in collection of Joseph A. Gillett.

Host.—Presumably *Artemisia tridentata,* since most of the above specimens are recorded as being from that plant.

Ceratagallia bigeloviae (Baker) Fig. 6

Agallia bigeloviae Baker, Psyche **7**(suppl. 12): 26. 1896.

Ceratagallia bigeloviae (Baker), Kirkaldy, Hawaiian Sugar Planters' Assoc. Expt. Sta., Div. Ent. Bull. **4**: 61. 1907.

Agallia (*Aceratagallia*) *bigeloviae* Baker, Van Duzee, Check List Hemiptera, p. 64. 1916.

Aceratagallia bigeloviae (Baker), Oman, U. S. Dept. Agr. Tech. Bull. **372**: 66. 1933.

A small, robust species marked with brown or fuscous. Style without a prominent heel and with the ventral tooth located distad of narrowest part of shank. Length 2.5–2.75 mm.

External characters.—General color sordid yellowish white; markings, except the pair of fuscous spots on crown, usually pale brown and indefinite but sometimes fuscous. Median portion of face often tinged with pink. Male plates comparatively large, tapering gradually from base to apex. Median lobes of seventh sternite of female shorter than lateral lobes and bluntly pointed.

Internal male genitalia.—Shank of style rather stout, inner margin nearly straight. Ventral tooth small and located distad of the constricted portion of shank. Posterior margin of style evenly curved from heel to toe; heel usually forming a right angle; toe slightly attenuated. Apex of aedeagus slightly hooked.

Localities.—Type locality, Albuquerque, N. Mex. Type, U.S.N.M. no. 44014. Other material examined from the following localities. TEXAS: Marfa and Taylor County. KANSAS: Phillips County. COLORADO: Fort Collins. UTAH: Leeds, Provo, Salt Lake City, Santa Clara, and St. George. ARIZONA: Congress Junction, Grand Canyon, Prescott, and Yavapai County. NEW MEXICO: Carlsbad, Colfax County, Las Cruces, Organ Mountains, Roswell, and White Sands.

Host.—Probably *Chrysothamnus.*

Notes.—There still remains some doubt as to the exact identity of *bigeloviae.* The type is a female and consequently difficult to identify with certainty; other specimens from the type locality are needed. Furthermore, the material studied and here treated as *bigeloviae* shows some variation around a mean which seems best exemplified by specimens from southern New Mexico. Specimens at hand from California are uniformly darker colored than material from other localities and may constitute a distinct form, but at present seem inseparable on the basis of structural characters.

Ceratagallia socala, n. sp. Fig. 7

Related to *artemisia* but less robust and with a more tumid head. Ventral tooth of style larger than that of *artemisia* and located on foot. Length 2.6–2.9 mm.

External characters.—General color pale cinereous; markings mostly very variable, the most constant being those on the pronotum and forewings. Spots on crown above ocelli usually distinctly ovate, occasionally absent. Head tumid, distinctly longer medially than next eye. Male plates proportionally smaller than those of *artemisia.* Median lobes of seventh sternite of female short and blunt.

Internal male genitalia.—Shank of style rather short and straight, tapering gradually from base to narrowest part, then abruptly expanded into the footlike distal part. Ventral tooth rather large and pointed, located on the foot of the style. Inner margin of shank rather coarsely serrate distally; heel scarcely produced; toe broad basally, apex slightly attenuate. Apex of aedeagus pointed.

Localities.—Type locality, Santa Maria, Calif. Holotype male, allotype female, and 16 male and 17 female paratypes collected July 19, 1933, R. H. Beamer. Also 13 male and 8 female paratypes from San Jacinto Mountains, Calif., June 30, 1933, R. H. Beamer. Types in collection of University of Kansas, paratypes in U. S. National Museum, no. 53354.

Host.—Unknown.

Ceratagallia ovata (Oman), n. comb. Fig. 8

Aceratagallia ovata Oman, Journ. Kansas Ent. Soc. **8**: 14. 1935.

A robust species, larger than *bigeloviae.* Shank of style much broader basally than distally; ventral tooth broad. Length 2.75–3 mm.

External characters.—General ground color pale yellow; markings mostly faint or absent except for oval spots on crown, basal triangles on scutellum, and markings on forewings. Clypeus usually tinged with pink. Male plates about twice as long as their combined basal width, tapering rather abruptly. Median lobes of seventh sternite of female shorter than lateral lobes, but well produced and bluntly pointed.

Internal male genitalia.—Shank of style broad basally, but tapering sharply to a rather slender median portion. Ventral tooth broad basally, located just basad of foot of style. Inner margin of shank finely serrate distally; heel scarcely produced; toe large, broader than narrowest part of shank and with tip slightly attenuate. Aedeagus with a blunt tooth near apex.

Locality.—Type locality, Yarnell Heights, Ariz. Type, U.S.N.M. no. 50368. There are also specimens at hand from Mojave, Calif.

Host.—Unknown.

Ceratagallia neovata, n. sp. Fig. 9

Resembling *socala* in general appearance, but with a less tumid head. Style similar to that of *ovata*, but more slender basally. Length 2.7–2.9 mm.

External characters.—General ground color pale cinereous; markings on pronotum faint, others usually distinct but not sharply delimited. Male plates as in *lobata.* Median lobes of seventh sternite of female bluntly pointed and nearly as long as lateral lobes.

Internal male genitalia.—Shank of style much more slender basally than in *ovata*, slightly sinuate and tapering gradually to footlike extremity. Ventral tooth small and bluntly pointed. Inner margin of shank finely serrate distally; heel small; toe slenderer and tip more attenuate than in *ovata.* Aedeagus with blunt tooth near apex.

Localities.—Type locality, Warner Springs, Calif. Holotype male, allotype female, and 1 male paratype, June 3, 1935, P. W. Oman, U.S.N.M. no. 53355. Also 1 male paratype from Beaumont, Calif., July 26, 1933, R. H. Beamer, in collection of the University of Kansas.

Host.—Unknown.

Ceratagallia tergata (Van Duzee), n. comb. Fig. 10

Agallia tergata Van Duzee, Proc. California Acad. Sci. (4) **12:** 172. 1923.
Aceratagallia tergata (Van Duzee), Oman, U. S. Dept. Agr. Tech. Bull. **372:** 69. 1933.

A comparatively large, robust species, usually without markings. Male plates short and broad. Length 3–3.25 mm.

External characters.—General ground color pale, sordid cinereous; markings usually entirely absent but sometimes present, particularly those along median line of head and pronotum and veins of corium. Clypeus sometimes suffused with pale orange. Entire body sometimes with a whitish bloom. Male plates broad, scarcely tapering from base to blunt apex. Median lobes of seventh sternite of female rather short and bluntly pointed, median emargination between these lobes unusually wide and deep.

Internal male genitalia.—Shank of style distinctly sinuate. Ventral tooth rather small, situated well basad of apex of style. Inner margin of shank finely serrate distally; heel small; toe rather long, with apex curved slightly cephalad. Apex of aedeagus hooked.

Localities.—Type locality, Tortuga Island, Gulf of California. Type in collection of the California Academy of Sciences. Other material from the following localities examined: California: Beaumont, Coachella, Riverside, and Soboba Springs. Arizona: Sabino Canyon, Santa Rita Mountains, and Tucson.

Host.—*Encelia.*

Ceratagallia longipes, n. sp. Fig. 11

Closely related to *tergata*, but with ovate spots on crown always present, and shank of style not sinuate. Length 3–3.25 mm.

External characters.—General ground color pale cinereous. Spots on crown small, other markings usually absent, although the basal triangles on scutellum and faint marks on distal portions of forewings are occasionally present. Clypeus usually very faintly tinged with pink. Male plates more slender than those of *tergata*, and tapering slightly from base to apex. Median lobes of seventh sternite of female as in *tergata.*

Internal male genitalia.—Shank of style relatively straight. Ventral tooth small, located basad of narrowest part of shank. Inner margin of shank serrate distally; heel but little produced; toe greatly produced and slender, thus making the foot of the style very long. Apex of aedeagus hooked.

Localities.—Type locality, Mojave, Calif. Holotype male, allotype female, and 11 male and 5 female paratypes collected July 7, 1933, R. H. Beamer. Other paratypes: 2 males and 5 females from Kelso, Calif., June 9, 1908, E. D. Ball; 1 male from Big Bear Lake, Calif., July 26, 1932, R. H. Beamer; 1 male from Palm Springs, Calif., May 23, 1917, E. P. Van Duzee; and 2 females from Palm Springs, Calif., May 21, 1917, E. P. Van Duzee. Holotype, allotype, and paratypes in collection of the University of Kansas, paratypes in collections of the U. S. National Museum, no. 53356, the California Academy of Sciences, and E. D. Ball.

Host.—Unknown.

Ceratagallia delta, n. sp. Fig. 12

A rather robust, well-marked species with very broad male plates and long median lobes of the seventh sternite of the female. Length 3.1–3.25 mm.

External characters.—General ground color sordid yellowish white; markings mostly of brown or fuscous and distinct, the oval spots on crown comparatively large. Head distinctly produced and tumid medially. Male plates very broad and scarcely tapering from base to apex, caudal opening of pygofer unusually large. Median lobes of seventh sternite of female nearly as long as lateral lobes, rather slender and slightly divergent distally, the median emargination between them narrow.

Internal male genitalia.—Shank of style long and rather slender, with a distinct bend near base. Ventral tooth blunt, located on base of foot of style. Inner margin of shank minutely serrate distally; heel small; toe slender and pointed. Apex of aedeagus blunt.

Locality.—Type locality, Delta, Calif. Holotype male, allotype female, and 41 male and 23 female paratypes collected June 28, 1935, P. W. Oman, U.S.N.M. no. 53357.

Host.—Unknown.

Ceratagallia vastitatis (Oman), n. comb. Fig. 13

Aceratagallia vastitatis Oman, U. S. Dept. Agr. Tech. Bull. **372**: 69. 1933.

Less robust than *delta*, with male plates smaller and the shank of the style nearly straight. One of the largest species in the genus. Length 3.5–3.75 mm.

External characters.—General ground color pale sordid yellow; markings mostly brown and rather indefinite except for the pair of fuscous spots on crown. Head scarcely produced medially. Male plates broad, but not so broad as those of *delta*, tapering slightly from base to apex. Median lobes of seventh sternite of female bluntly pointed, nearly equal to lateral lobes in length.

Internal male genitalia.—Shank of style nearly straight, not tapering distally. Ventral tooth small, located on base of foot. Posterior margin evenly rounded; inner margin of shank very finely serrate distally; heel scarcely produced; toe well produced and bluntly pointed. Apex of aedeagus slightly hooked.

Localities.—Type locality, Lund, Utah. Type, U.S.N.M. no. 44017. Material from the following localities examined: UTAH: Dixie, Leeds, and

Lund. NEVADA: Glendale, Las Vegas, and Overton. CALIFORNIA: Indio, Fort Yuma, and Potholes. ARIZONA: Littlefield and Yuma.

Host.—*Pluchea sericea.*

Ceratagallia aplopappi (Oman), n. comb. Fig. 14

Aceratagallia aplopappi Oman, U. S. Dept. Agr. Tech. Bull. **372**: 67. 1933.

A robust species, easily separated from other species of the genus by the strongly arched male plates. Length 2.75–3 mm.

External characters.—General ground color pale yellow; markings, except the pair of fuscous spots on crown, varying from pale yellowish brown to fuscous. Male plates strongly arched downward, broad basally, tapering gradually to the rounded and slightly divergent apices. Male pygofer with numerous fine, white hairs laterally. Median lobes of seventh sternite of female as long as lateral lobes, pointed and closely appressed to the pygofer, which is usually shallowly grooved for their reception.

Internal male genitalia.—Shank of style slightly sinuate, not tapered distally. Ventral tooth absent. Inner margin of shank finely serrate distally; heel rounded and serrate, with the adjacent surface of the foot finely dentate; apex of toe bluntly rounded. Apex of aedeagus slightly hooked.

Localities.—Type locality, Pima County, Ariz. Type in collection of the University of Kansas. Material from the following localities examined: ARIZONA: Baboquivari Mountains, Benson, Coconino County, Maricopa County, Mescal, Phoenix, Pima County, Red Rock, Sabino Canyon, Santa Rita Mountains, Sasabe, Tempe, Tucson, and Yarnell Heights. NEW MEXICO: Belen.

Host.—*Aplopappus.*

Ceratagallia ludora, n. sp. Fig. 15

A robust species with a short, broad head. Shank of style more slender basally than distally. Length 3–3.2 mm.

External characters.—General ground color pale cinereous, head tinged with pale yellow; markings, except the pair of fuscous spots on crown, mostly indefinite. Male plates rather large, about as in *vastitatis.* Median lobes of seventh sternite of female as long as lateral lobes, tips rounded.

Internal male genitalia.—Shank of style with base rather strongly curved and more slender than distal portion. Ventral tooth located on foot of style. Inner margin of shank finely, irregularly serrate distally; heel scarcely produced; toe broad, apex attenuate. Aedeagus with a small tooth near apex.

Localities.—Type locality, Perris, Calif. Holotype male, allotype female, and 3 male and 2 female paratypes collected June 5, 1935, P. W. Oman, U.S.N.M. no. 53358. Also the following paratypes from San Diego County, Calif., collected by E. P. Van Duzee: 1 male, April 22, 1913; 1 male and 1 female, October 3, 1913(?); and 1 male March 11, 1914. In collection of California Academy of Sciences.

Host.—Unknown.

Ceratagallia canona, n. sp. Fig. 16

A rather slender species with head slightly produced. Shank of style nearly straight, foot of style slender. Length 3–3.5 mm.

External characters.—General ground color pale cinereous, head often tinged with pale yellow; markings frequently indistinct, the pair of fuscous spots on crown usually ovate and oblique. Male plates comparatively large tapering gradually from base to apex. Median lobes of seventh sternite of female slightly shorter than lateral lobes, diverging slightly, tips bluntly pointed.

Internal male genitalia.—Shank of style rather slender. Ventral tooth slender and sharply pointed, located on foot of style. Inner margin of shank finely serrate on distal half; heel well produced and ending in a sharp point; toe rather slender and sharply pointed. Apex of aedeagus blunt.

Localities.—Type locality, Mint Canyon, Calif. Holotype male, allotype female, and 6 male and 5 female paratypes collected June 7, 1935, P. W. Oman, U.S.N.M. no. 53359. Also 4 male and 10 female paratypes from Beaumont, Calif., July 26, 1933, R. H. Beamer, in collection of University of Kansas, and the following paratypes from California, collected by E. P. Van Duzee, and deposited in the California Academy of Sciences: 2 males, San Diego County, June 18, 1913; 1 male, Alpine, September 13, 1923; and 1 male and 1 female, Mint Canyon, April 20, 1932.

Host.—Unknown.

Ceratagallia tristis, n. sp. Fig. 17

A rather slender species, related to *canona*, but darker colored and with the shank of the style more slender and curved. Length 3.2–3.4 mm.

External characters.—General ground color sordid yellowish white, head and anterior portion of pronotum tinged with pink; markings mostly fuscous usually not sharply delimited on fore wings, and sufficiently extensive to give the entire insect a fuscous appearance. White mark on base of R+M conspicuous. Male plates rather slender, tapering gradually from base to apex. Median lobes of seventh sternite of female short and blunt, the median emargination separating them broadly V-shaped, the lateral emarginations narrow.

Internal male genitalia.—Shank of style broadly curved, tapering slightly from base. Ventral tooth prominent, located just basad of outer point. Inner margin of shank irregularly serrate on distal two-thirds; heel well produced and usually bifid; apex of toe slightly attenuate. Apex of aedeagus hooked.

Localities.—Type locality, Perris, Calif. Holotype male, allotype female, and 2 male and 6 female paratypes collected June 5, 1935, P. W. Oman, U.S.N.M. no. 53360. Other paratypes from California as follows: 1 male, San Francisco, April 27, 1908, E. D. Ball, in collection of E. D. Ball; 1 male, San Francisco, April 18, 1917, W. M. Giffard, in collection of California Academy of Sciences; 3 males, Beaumont, July 26, 1933, R. H. Beamer; 1 male, Winters, August 5, 1929, R. H. Beamer; 1 female, Alpine, July 9, 1929, R. H. Beamer, in collection of the University of Kansas.

Host.—Unknown.

Ceratagallia arroya, n. sp. Fig. 18

A robust species, usually heavily marked with fuscous. Style similar to that of *tristis* but stouter and with shank less strongly curved. Length 3.1–3.4 mm.

External characters.—General ground color pale cinereous; markings unusually dark, especially those on the crown and pronotum, the white areas on fore wings thus conspicuous in contrast. Head slightly produced medially. Male plates much wider basally than distally. Median lobes of seventh sternite of female rather short, diverging and bluntly pointed.

Internal male genitalia.—Shank of style slightly curved. Ventral tooth prominent and pointed, located a little more basad than that of *tristis*. Inner margin of shank finely and irregularly serrate on distal half; heel bifid but proportionally smaller than that of *tristis;* toe slightly attenuate. Apex of aedeagus slightly hooked.

Localities.—Type locality, Saugus, Calif. Holotype male, allotype female, and 17 male and 17 female paratypes collected June 7, 1935, P. W. Oman, U.S.N.M. no. 53361. Also 17 male and 12 female paratypes from Mill Creek Canyon, San Bernardino Mountains, Calif., collected September 23–25, 1923, by E. P. Van Duzee, in collection of California Academy of Sciences. There are also specimens at hand from the following California localities: Lompoc, Ontario, Pasadena, and San Diego County.

Host.—*Eriodictyon.*

Ceratagallia neodona, n. sp. Fig. 19

Closely related to *dondia,* but style with a longer toe and a much smaller ventral tooth. Length 3.6–3.9 mm.

External characters.—General ground color pale yellowish cinereous; markings, except the pair of small fuscous spots on crown, usually faint or absent, when present brown veins of the forewings and the traces of the lateral arcs on pronotum are most prominent. Male plates rather slender, tapering distally. Median lobes of seventh sternite of female rather small, bluntly pointed and diverging, the lateral emarginations separating them from the lateral lobes very narrow.

Internal male genitalia.—Shank of style stout. Ventral tooth pointed, located just basad of foot of style. Inner margin of shank serrate on distal half; heel small; toe comparatively large and considerably longer than that of *dondia,* apex slightly attenuate. Apex of aedeagus slightly hooked.

Locality.—Type locality, Nixon, Nev. Holotype male, allotype female, and 5 female paratypes collected June 20, 1927, 7 female paratypes collected June 30, 1927, by E. P. Van Duzee. Types in collection of California Academy of Sciences, 4 paratypes in collection of U. S. National Museum, no. 53362.

Host.—Unknown.

Ceratagallia pera, n. sp. Fig. 20

Closely related to *arroya* and *dondia,* but with toe of style very large and ventral tooth of style larger than in either of those species. Length 3.6–3.9 mm.

External characters.—General ground color pale yellow or yellowish cinereous; markings very faint or absent, except the pair of small fuscous spots on crown and sometimes the brown veins of forewings. Male plates comparatively small, tapering sharply from base to apex. Lobes of seventh sternite of female short, median lobes blunt.

Internal male genitalia.—Shank of style stout and of nearly uniform width. Ventral tooth very large and angular, located just basad of foot of style. Inner margin of shank coarsely and irregularly serrate on distal two-thirds; heel rather small; toe very large, apex pointed but not attenuate. Apex of aedeagus blunt.

Locality.—Type locality, Perris, Calif. Holotype male, allotype female, and 14 male and 20 female paratypes collected June 5, 1935, P. W. Oman, U.S.N.M. no. 53363.

Host.—Unknown.

Ceratagallia califa, n. sp. Fig. 21

Related to *pera,* which it resembles in general appearance, but style with a smaller ventral tooth and a larger heel. Length 3.2–3.75 mm.

External characters.—General ground color yellowish white; markings usually either very faint or entirely absent, the pair of spots on crown, when present, small and elongate-ovate in shape. Male plates similar to those of *pera*, but slightly longer. Lobes of seventh sternite of female short and blunt.

Internal male genitalia.—Shank of style more slender and more curved than that of *pera*. Ventral tooth prominent and angular, located just basad of inner point. Posterior margin of style very shallowly emarginate; inner margin of shank irregularly serrate on posterior two-thirds; heel well produced and pointed; toe large and blunt, with a nipplelike projection at laterocephalic angle. Apex of aedeagus slightly hooked.

Localities.—Type locality, Califa, Calif. Holotype male, allotype female, and 22 male and 36 female paratypes collected June 12, 1935, P. W. Oman, U.S.N.M. no. 53364. Also 4 male and 5 female paratypes from Selma, Calif., June 4, 1929, E. P. Van Duzee, in collection of California Academy of Sciences. Other specimens from Los Banos and Bakersfield, Calif., examined.

Host.—Probably *Dondia.*

Ceratagallia dondia (Oman), n. comb. Fig. 22

Aceratagallia dondia Oman, U. S. Dept. Agr. Tech. Bull. **372**: 68. 1933.

A large, rather robust species. Style with a relatively short toe and a large, angular, ventral tooth, Length 3.4–3.75 mm.

External characters.—General ground color pale yellow; markings, with the exception of the pair of fuscous spots on crown, frequently faint or absent, when present usually brown but occasionally fuscous. Male plates comparatively slender, width basally about twice the apical width. Median lobes of seventh sternite of female shorter than lateral lobes and bluntly rounded.

Internal male genitalia.—Shank of style nearly straight and rather broad basally. Ventral tooth large and angular, located just basad of foot of style at narrowest part of shank. Posterior margin of style broadly and rather uniformly rounded; inner margin of shank finely and irregularly serrate; heel well produced and angular; toe rather short, about as long as greatest width of shank, apex angled but not attenuate.

Localities.—Type locality, Thermal, Calif. Type, U. S. N. M. no. 44016. Other material from the following localities examined. CALIFORNIA: Catalina Island, Coachella, Fort Yuma, and Panamint Mountains. NEVADA: Bunkerville, Las Vegas, and Overton. UTAH: Delta, Grantsville, and Leeds. ARIZONA: Sacaton, Tucson, and Yuma. COLORADO: Grand Junction and Rocky Ford. TEXAS: El Paso.

Host.—Dondia.

Ceratagallia loma, n. sp. Fig. 23

Resembling *artemisia* and *bigeloviae* in size and general form, but more closely related to *grisea* on the basis of the shape of the style. Smaller than grisea and with the shank of the style more coarsely serrate. Length 2.6–2.7 mm.

External characters.—General ground color sordid cinereous, head tinged with yellow; markings mostly fuscous and sharply delimited, the median stripes on crown diverging posteriorly. A robust species with head slightly tumid. Male plates comparatively large, very little narrowed distally. Median emargination in posterior margin of seventh sternite of female broad but not angular; median lobes short and blunt.

Internal male genitalia.—Shank of style slightly sinuately curved, broader basally than near foot. Ventral tooth rather large and angular, located just distad of narrowest part of shank. Inner margin of shank coarsely and irregularly serrate except basally; heel well produced and slightly bifid; toe rather broad, with anterolateral angle attenuated. Apex of aedeagus slightly hooked.

Locality.—Type locality, Warner Springs, Calif. Holotype male, allotype female, and 1 male paratype collected June 3, 1935, P. W. Oman, U.S.N.M. no. 53365.

Host.—Unknown.

Ceratagallia grisea (Oman), n. comb. Fig. 24

Aceratagallia grisea Oman, Journ. Kansas Ent. Soc. **8**: 13. 1935.

A robust gray species marked with fuscous. Style with shank rather slender and toe broad and short. Length 3 mm.

External characters.—General ground color pale gray, clypeus tinged with pink; markings usually sharply delimited. Pronotal markings variable, those most often present being the two median stripes and a spot near each lateral margin which represents a trace of the lateral stripe. Male plates rather long and slender, tapering gradually from base to apex. Median emargination in posterior margin of seventh sternite of female broadly V-shaped, median lobes bluntly pointed and nearly as long as lateral lobes.

Internal male genitalia.—Shank of style slightly sinuate, becoming narrower distally. Ventral tooth blunt, located at base of foot of style. Inner margin of shank irregularly serrate; heel well produced and usually bifid; toe broad and relatively short, the anterolateral angle less attenuated than in *loma*. Apex of aedeagus slightly hooked.

Locality.—Type locality, Ramsey Canyon, Huachuca Mountains, Ariz. Type, U.S.N.M. no. 50367.

Host.—Unknown.

Ceratagallia lupini, n. sp. Fig. 25

A robust species, related to *grisea* but larger and paler, the style with shank more strongly curved and toe broader. Length 3.4–3.9 mm.

External characters.—General ground color sordid white to pale gray, head sometimes tinged with pale yellow. Markings frequently entirely absent, always considerably reduced and usually faint. Head slightly tumid. Male plates as in *grisea*. Male pygofer with numerous fine white hairs laterally. Median lobes of seventh sternite of female bluntly pointed and slightly shorter than lateral lobes, the median emargination separating them not angular.

Internal male genitalia.—Shank of style strongly, sinuately curved. Ventral tooth located on base of foot of style. Inner margin of shank irregularly serrate on distal two-thirds; heel well produced; toe very broad and blunt, the antero-lateral angle not attenuated.

Localities.—Type locality, Three Rivers, Calif. Holotype male, allotype female, and 19 male and 28 female paratypes, collected June 9, 1935, P. W. Oman, U.S.N.M. no. 53366. Other paratypes, 14 males and 14 females from San Francisco, Calif., June 20, 1935, P. W. Oman, and 5 males and 13 females from Santa Maria, Calif., July 19, 1933, R. H. Beamer.

Host.—*Lupinus*.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

NEW MEMBERS ELECTED

The following have recently been elected to membership in the Academy:

Active resident members:

- Charles Armstrong, senior surgeon, U. S. Public Health Service, in recognition of his contributions in the fields of medical bacteriology and immunology and particularly for his studies on poliomyelitis and lymphocytic chorio-meningitis.
- Raymond McGeary Hann, chemist, National Institute of Health, in recognition of his contributions to the chemistry of sugars and related compounds.
- William Vincent Lambert, senior animal husbandman, in charge, Genetics Division, U. S. Bureau of Animal Industry, in recognition of his contributions to avian and mammalian genetics, especially in the field of inheritance of disease resistance and of inbreeding.
- Harald Alfred Rehder, assistant curator, Division of Mollusks, U. S. National Museum, in recognition of his scientific attainments in the field of malacology.
- Francis Owen Rice, head of the Department of Chemistry, Catholic University of America, in recognition of his contributions to the study of the kinetics of organic reactions, in particular his researches on free radicals.
- Irl Corley Schoonover, associate chemist, National Bureau of Standards, in recognition of his contributions to potentiometric methods of chemical analysis and the properties of silver and dental materials.
- J. Leon Shereshefsky, chairman of the Department of Chemistry, Howard University, in recognition of his work on capillarity, adsorption, and surface tension.
- William R. Van Dersal, biologist, U. S. Soil Conservation Service, in recognition of his work on food plants of native game.
- Milton Victor Veldee, surgeon, U. S. Public Health Service, in recognition of his contributions to medical bacteriology, immunology, and epidemology, in particular his studies on scarlet fever.
- Ernest Pillsbury Walker, assistant director, National Zoological Park, Smithsonian Institution, in recognition of his attainments in biology, with special reference to mammals.

Active nonresident members:

- Carl John Drake, head of the Department of Zoology and Entomology, Iowa State College, and State Entomologist, Ames, Iowa, in recognition of his contributions to the taxonomy of the Hemiptera, especially the families Tingitidae and Gerridae.
- William Albert Hoffman, assistant professor of parasitology, School of Tropical Medicine, San Juan, P. R., in recognition of his contributions to medical entomology and parasitology.
- Robert Matheson, professor of entomology, Cornell University, Ithaca, N. Y., in recognition of his researches in medical entomology, particularly his work on the taxonomy of mosquitoes.

Honorary members:

CARLOS DE LA TORRE Y DE LA HUERTA, School of Sciences, University of Havana, Havana, Cuba, in recognition of his scientific attainments.

HENRI F. PITTIER, botanist and administrator of Agriculture, Caracas, Venezuela, in recognition of his contributions to the botany of South and Central America.

LEONHARD STEJNEGER, head curator of biology, U. S. National Museum, in recognition of his contributions to herpetology, ornithology, and mammalogy.

INCREASE IN RESIDENT MEMBERS VOTED

As a result of the balloting ending July 4, 1939, the membership of the Academy overwhelmingly voted to increase the number of resident active members from 400 to 450. There are, therefore, approximately 50 vacancies in the resident membership. This is brought to the attention of the members with the suggestion that they nominate those from among their associates who are eligible for membership. Nomination blanks may be obtained from the Corresponding Secretary and should be returned to the present Chairman of the Membership Committee, E. W. PRICE, U. S. Bureau of Animal Industry.

AWARDS FOR SCIENTIFIC ACHIEVEMENT

At its meeting on October 20, 1939, the Board of Managers of the Academy voted the establishment of awards for noteworthy discovery, accomplishment, or publication in the physical, biological, and engineering sciences, respectively. An award will be presented in each of these three fields not oftener than once in any calendar year. The awards, which will take the form of suitably inscribed certificates and be appropriately presented, will be limited to persons 40 or less years of age who are members of the Academy, resident or nonresident, or to members of societies affiliated with the Academy resident in the Washington area. The Committee on Awards, which has been appointed by the President of the Academy, will make recommendations each year to the Board of Managers not later than the annual meeting of the Academy, and the first awards may be made for the calendar year 1940. President CHAMBLISS has divided the Committee on Awards (JAMES F. COUCH, temporary chairman) into three subcommittees, one for each of the three fields of science concerned: *Biological Sciences,* AUSTIN H. CLARK, FREDERICK A. COE, JOHN M. COOPER, HOWARD A. EDSON, E. A. GOLDMAN (temporary chairman), H. W. SCHOENING, GOTTHOLD STEINER, ALEXANDER WETMORE; *Physical Sciences,* ARNOLD K. BALLS, OSCAR S. ADAMS, FERDINAND G. BRICKWEDDE, JAMES F. COUCH (temporary chairman), W. EDWARDS DEMING, OLIVER H. GISH, OSCAR E. MEINZER, FRED L. MOHLER, WALDEMAR T. SCHALLER, GEORGE TUNELL, ROGER C. WELLS, EDGAR W. WOOLARD, OLIVER R. WULF; *Engineering Sciences,* WILLIAM BOWIE, HARVEY L. CURTIS (temporary chairman), FRANCIS M. DEFANDORF, HERBERT G. DORSEY, JOHN W. MCBURNEY, H. L. WHITTEMORE, PAUL C. WHITNEY.

PUBLICATION OF MONOGRAPHS

It has been felt for some time that much valuable scientific material has been lost for want of publication and that the Academy should undertake the publication of scientific monographs to care for part of this problem

Accordingly, at its meeting on October 20, 1939, the Board of Managers of the Academy approved the establishment of a Committee on Monographs, whose functions will be to select appropriate manuscripts and arrange for their publication in the form of monographs. Preference will be given to manuscripts prepared by members of the Academy. The Committee on Monographs consists of six members, each appointed to serve a term of three years, except that of the first appointees, two are for one year, two are for two years, and two are for three years, and that the retiring Senior Editor of the JOURNAL is one of the two new members annually appointed to this committee. To carry out the work of the Committee on Monographs, the Academy has established a revolving fund of $1,000, which will be used to underwrite the publication of the first monographs. Receipts from the sale of monographs will be credited to this fund and used to finance the publication of future monographs. President CHAMBLISS has appointed the following to serve as the Committee on Monographs: for one year, FREDERICK D. ROSSINI, JOHN A. STEVENSON; for two years, ROLAND W. BROWN, EBEN H. TOOLE; for three years, HENRY B. COLLINS, JR. (chairman), EMMETT W. PRICE. Proposals from authors concerning the publication of such monographs should be sent to HENRY B. COLLINS, JR., Smithsonian Institution, Washington, D. C.

CUSTODIAN AND SUBSCRIPTION MANAGER OF PUBLICATIONS

On May 5, 1939, the Board of Managers of the Academy created the office of Custodian and Subscription Manager of Publications. This officer, appointed for a term of three years, shall handle correspondence with new subscribers and subscription agencies, shall have charge of all reserve stocks of the Academy's publications, shall inaugurate a program to increase the sale of back numbers and complete sets of the JOURNAL, shall fill orders for the purchase of back numbers and sets, shall maintain at all times a detailed inventory of reserve stocks of back literature, and shall submit to the Board of Managers at the end of each year a detailed account of his activities. President CHAMBLISS has appointed W. W. DIEHL, of the U. S. Bureau of Plant Industry, to this new office.

CHEMICAL SOCIETY

509TH MEETING

The 509th meeting and the annual dinner of the Society were held in the auditorium of the Cosmos Club on Thursday, March 9, 1939, with President KRACEK acting as toastmaster. Following the dinner, Past President N. L. DRAKE was introduced. He briefly reviewed the past history of the Hillebrand Prize Award, spoke of some of its objectives, and introduced the 1938 recipients. President KRACEK then presented the award in a brief and dignified ceremony to RALEIGH GILCHRIST and EDWARD WICHERS for their contribution entitled *A new system of analytical chemistry for the platinum metals.* The next speaker was Professor JAMES LEWIS HOWE, of Washington and Lee University, who spoke in a delightful manner of the early history of research in platinum metal chemistry in this country, leavening his remarks with many personal reminiscences. The two recipients were next introduced. EDWARD WICHERS spoke on *Glimpses of platinum metal chemistry,* outlining the basic problem, and the mode of attack that has led to its solution in the laboratories of the National Bureau of Standards. RALEIGH GILCHRIST gave *Reminiscences* of the research, which has, incidentally, led to the production of platinum metals of known and controllable purity, for it is found that many of the analytical procedures, when employed on large scale lots, lead to the economical production of the pure metals in competition with the methods that formerly led to relatively impure products.

510TH MEETING

The 510th meeting was held in the auditorium of the Cosmos Club on Thursday, April 13, 1939, President KRACEK in the chair. After the reading of the minutes the Society was addressed by WARREN E. EMLEY, chief of the Organic and Fibrous Materials Division, National Bureau of Standards:

WARREN E. EMLEY: *Testing of plastics and the significance of the results.*—The variety of plastics commercially available is now very large. Manufacturers have sufficient control of their processes to vary the properties of their products within large limits. If a prospective consumer can tell the manufacturer just what properties he desires, he can probably find some manufacturer willing to undertake to make an article having those properties. Before this can be done, however, it is essential that accepted test methods be available. Otherwise the consumer will not be able to make his wants known in a manner intelligible to the manufacturer. The development of such test methods is now the major objective of the work of Committee D-20 on Plastics, of the American Society for Testing Materials. (*Author's abstract.*)

511TH MEETING

The 511th meeting was held at the University of Maryland, College Park, Md., on Thursday, May 11, 1939, President KRACEK presiding. The meeting was preceded by an informal dinner in the University Dining Hall. After the reading of the minutes the Society divided into three sections for the reading of papers.

Section of Analytical Chemistry, C. E. WHITE presiding:

A. KEITH BREWER: *The application of the mass spectrograph to the study of isotope abundance and atomic weights.*—Two types of mass spectrographs are in use at the present time. The Aston combined energy and momentum analyzer is used for accurate determinations of mass, and the Dempster 180° momentum analyzer for determinations of abundance ratios. Within the past few years mass spectrograph design and technique have been so simplified and perfected that high precision instruments can now be built at comparatively moderate cost.

The principal use of the mass spectrograph at the present time is for the determination of isotope abundance ratios. From such measurements on lead and uranium an estimate of the geological age of the rocks can be obtained, while from similar measurements on potassium and calcium, or rubidium and strontium minerals, the age of matter itself can be computed. Atomic weights of most of the elements can be determined directly from the abundance ratios; the accuracy is comparable with the best chemical technique for absolute weights and materially better for comparative values. Abundance measurements have shown that the atomic weights of several of the elements are not constant in nature but vary between appreciable limits. Very small quantities of material are needed in determining isotope abundance ratios. In the case of potassium, 10^{-4} gms of any potassium containing material is all that is required, while 10^{-10} gms of potassium can be detected; no chemical treatment is necessary.

New uses for the mass spectrograph are continually being found. Doubtless the most important application is in the analysis of biological tissues for natural isotopes used as "indicators" in metabolic studies. Recent developments of methods for concentrating isotopes and the phenomenal results that have been obtained bid fair to make the mass spectrograph a necessary instrument for the biochemist. The mass spectrograph has great possibilities in the field of analytical chemistry; this is especially true in the analyses of trace elements where extreme sensitivity is necessary. (*Author's abstract.*)

LOUIS L. MADSEN and RUSSELL E. DAVIS: *Studies on the determination of carotene and vitamin A in blood plasma with the spectrophotometer.*—Spectrophotometric examinations have been made on extracts containing the nonsaponifiable fraction of cattle blood plasma. Extracts from carotene determinations were made to volume in a mixture of equal parts absolute ethyl alcohol and a higher boiling petrolic ether (B. P. 90°–98° C) after being extracted according to the principle of the Willstätter and Stoll procedure. By definition, the material corresponding to the theoretical beta-carotene absorption measured at 430, 436, 450, and 480mμ is listed as carotene, while the nonsaponifiable material of blood plasma which was soluble in cold methyl alcohol and had a selective absorption maximum at 328mμ was called vitamin A. In general, extracts from blood plasma which are high in carotene and vitamin A give absorption characteristics more nearly equal to theoretical values than extracts from blood plasma from animals that are low or deficient in these factors. Methods for the preparation of extracts that are free from compounds causing interfering absorption have not been developed.

Data are presented on determinations made on the blood plasma of beef heifers fed normal and carotene-deficient rations and a relation between the carotene intake and the carotene and vitamin A content of the blood plasma was demonstrated. Uncorrected values are recorded showing the carotene content of the plasma of normal animals to be as high as 11.7 micrograms per cc, while the highest vitamin A value found was 0.58 microgram per cc. For deficient animals the lowest blood carotene recorded was 0.06 microgram per cc, while the lowest vitamin A value found was 0.03 microgram per cc. It appears that the degree of carotenemia depends upon the exogenous supply and storage of carotene and therefore varies within wide limits, while the vitamin A content of the plasma reaches a less variable physiological level, which it maintains as long as the supply of carotene or vitamin A is adequate but which also decreases in the state of deficiency. (*Authors' abstract.*)

GEORGE M. MACHWART and MARRIOTT W. BREDEKAMP: *Acidity in petroleum oils: Electrometric titration method.*—A study of acidity in an oxidized petroleum oil by electrometric titration has indicated that: (1) Rate of formation of acidity may be independent of the rate of formation of sludge; (2) the amount of acidity present was found to be greater with certain inhibitors present in the oil than in the absence of these inhibitors. The apparatus used was found to be very sensitive to external factors and several recommendations were made to minimize the effect of these factors. It is believed that the electrometric titration method for the determination of acidity may be valuable in the development of the mechanism of inhibition and deterioration of motor lubricants. (*Authors' abstract.*)

Section of Organic and Biological Chemistry, N. L. DRAKE presiding:

LEWIS W. BUTZ, ADAM M. GADDIS, and ELEANORE W. J. BUTZ: *The synthesis of substances related to steroids.*—The steroids that have been synthesized from simpler nonsteroid compounds have contained one or more benzenoid rings. Of the 70 or 80 steroids that have been found in nature, 6 contain a benzenoid or naphthalenoid system; the others are alicyclic. We have studied some addition reactions of 1,3,5-hexatriene with a view to the development of synthetic methods for the preparation of the alicyclic type.

Hexatriene would be expected to add by a Diels-Alder reaction to unsaturated carbon-carbon bonds to give compounds containing a 3-vinylcyclohexene system. Although other types of addition can be foreseen, the Diels-Alder type occurs very generally with polyenes. If the 3-vinylcyclohexene derivative is formed, it will show a tendency to rearrange to isomers in which the two double bonds have become conjugated, although the experimental conditions under which such isomerization occurs have not been precisely determined. By migration of a single hydrogen atom, two secondary products can result, a 3-ethylidenecyclohexene and a 2-vinylcyclohexene. The latter is a reactive diene type and should add a mol of olefin to give a product which contains an 8-octalin system. The 3-ethylidenecyclohexene type has been found not to participate in the Diels-Alder reaction, but it might conceivably isomerize by migration of another hydrogen atom to an ethylcyclohexadiene which is a reactive diene type. It should therefore be possible, by supplying an active addend to the 3-vinylcyclohexene derivative, to diret isomerization preponderantly in the direction of formation of the 2-vinylcyclohexene and obtain in good yield a product which is essentially the result of the successive addition of two mols of olefin to hexatriene.

The synthetic route under investigation then consists of three steps:

I. hexatriene + olefin ⟶ 3-vinylcyclohexene
II. 3-vinylcyclohexene ⟶ 2-vinylcyclohexene
III. 2-vinylcyclohexene + olefin ⟶ 8-octalin

For the synthesis of a steroid the olefins in this, the shortest reaction series, must be a cyclopentene and a cyclohexene derivative. Other series consisting of addition of open chain compounds to a triene or dienyne system, followed by ring closure of the Diels-Alder or other type, may prove of greater practical importance.

Aside from one failure to add 1-methylcyclohexen-3-one to hexatriene, only one Diels-Alder addition to hexatriene has been reported. E. H. Farmer reported the synthesis of 6-ethylidene-1,2,3,6-tetrahydrophthalic anhydride from hexatriene and maleic anhydride at 100°. Since 6-vinyl-1,2,3,6-tetrahydrophthalic anhydride would be the expected product, isomerization was nearly complete. We have found, however, that by allowing hexatriene and maleic anhydride to react at 30°, a quite different adduct is obtained which is isomeric with Farmer's ethylidene-anhydride.

Naptho-1,4-quinone and hexatriene at 50° gave two products, a liquid and a solid. Present evidence indicates that the liquid is the expected vinyltetrahydroanthraquinone, that the solid is the ethylidenetetrahydroanthraquinone or ethyldihydroanthraquinone. Hexatriene and 4-acetoxylo-2,5-quinone gave two solid isomers of the expected empirical constitution. Hexatriene and *p*-xylo-2,5-quinone gave a liquid 1:1 adduct and a mixture of solid products from which a fraction with the composition of an adduct of one mol hexatriene with two mols xyloquinone was obtained. A similar product was obtained from the 1:1 adduct by heating with xyloquinone. In contrast to the other solid adducts reported here, which were crystalline, this interesting fraction from xyloquinone appeared to be amorphous and individual batches melted at different temperatures. Cyclopentene-1-aldehyde and 1-methylcyclopenten-5-one gave liquid adducts of the expected composition (hydroindenes) with hexatriene. (*Authors' abstract.*)

M. HARRIS and A. SOOKNE: *Electrophoresis studies of fiber (protein and cellulose) surfaces.*—No abstract available.

R. M. HANN, W. D. MACLAY, and C. S. HUDSON: *The structure of diacetone dulcitols.*—It is shown that the properties of the α- and β-diacetone dulcitols, as well as those of several new derivatives of these substances, exclude the possibility that they can be enantiomorphic substances and prove that they are structural isomers. Evidence has been obtained from periodate and lead tetraacetate oxidations that neither α- nor β-diacetone dulcitol contains a glycol grouping. The results of a study of the ditosyl, di-iodo, and ditrityl derivatives of β-diacetone dulcitol indicate that it contains two free primary hydroxyl groups, and a study of the oxidation of the diacyl dulcitols, derivable from it, proves that its structure is that of 2,3,4,5-diacetone dulcitol. The results of a study of the ditosyl, monotosyl monoiodo, and monotrityl monoacetyl derivatives of α-diacetone dulcitol indicate that it contains one free primary hydroxyl group and one free secondary hydroxyl group, and a study of the oxidation of the dibenzoyl dulcitol derived from it proves that it is 2,3,5,6-diacetone-*D,L*-galactitol. An acyl migration by which 1:4-dibenzoyl-*D,L*-galactitol (a racemic form) passes to 1:6 dibenzoyl dulcitol (a meso form) has been demonstrated.

A cyclic acetal shift has been shown to be the cause of the interesting and unusual changes which Fischer and Bergmann noticed upon acetylation of α-diacetone dulcitol. The shift occurs as a stage in the benzoylation of α-diacetone dulcitol with benzoyl chloride and quinoline or pyridine at elevated temperatures. In structural terms it is represented as the passage of 1:4-dibenzoyl-2,3,5,6-diacetone-*D,L*-galactitol to 1:6-dibenzoyl-2,3,4,5-diacetone dulcitol. (*Authors' abstract.*)

Section of Physical Chemistry, M. M. HARING presiding:

R. E. GIBSON and O. H. LOEFFLER: *The effect of pressure and temperature on the absorption of light by solutions of aromatic amines in nitrobenzene.*—No abstract available.

J. F. SCHAIRER: *The chemical composition of the rock-forming pyroxenes.*—The rock-forming pyroxenes constitute one of the most important mineral groups of the igneous rocks. They present exceptional complexity both of crystalline modifications and chemical composition, and are a series of solid solutions, some of the molecules of which are completely miscible and others only partly miscible. The important chemical molecules that enter into the composition of the rock-forming pyroxenes are: $CaSiO_3$, wollastonite, pseudowollastonite; $MgSiO_3$, enstatite, clinoenstatite; $CaSiO_3 \cdot MgSiO_3$, diopside; $FeSiO_3$, ferrosilite, clinoferrosilite; $CaSiO_3 \cdot FeSiO_3$, hedenbergite; $MnSiO_3$, rhodonite, bustamite; $CaSiO_3 \cdot MnSiO_3$, johannsenite; molecules containing Al_2O_3, augites; Fe_2O_3, augites and babingtonite; TiO_2, titaniferous augites; $Na_2O \cdot Al_2O_3 \cdot 4SiO_2$, jadeite; $Na_2O \cdot Fe_2O_3 \cdot 4SiO_2$, acmite, aegirite.

The three most important molecules are the metasilicates $CaSiO_3$, $MgSiO_3$ and $FeSiO_3$. Data for the stability relations between $CaSiO_3$—$FeSiO_3$ and $MgSiO_3$—$FeSiO_3$ have been given by Bowen and Schairer in papers on the systems CaO—FeO—SiO_2 and MgO—FeO—SiO_2, respectively. The relations between diopside ($CaMgSi_2O_6$) and $MgSiO_3$ are given by Bowen and Andersen in their paper on the system forsterite—diopside—silica. Data are presented here for the binary system $CaSiO_3$—diopside ($CaMgSi_2O_6$). In order to find the stability relations of the pyroxenes containing Al_2O_3, it will be necessary to study two quaternary systems: CaO—FeO—Al_2O_3—SiO_2 and MgO—FeO—Al_2O_3—SiO_2. The first of these is in progress and complete data for the ternary system, FeO—Al_2O_3—SiO_2, are presented. The incongruent nature of the melting of acmite ($Na_2O \cdot Fe_2O_3 \cdot 4SiO_2$) and complete melting relations for this mineral have been given by Bowen, Schairer, and Willems in their paper on the system Na_2SiO_3—Fe_2O_3—SiO_2. Data are at hand showing that jadeite ($Na_2O \cdot Al_2O_3 \cdot 4SiO_2$) near liquidus temperatures breaks down into nepheline and albite. (*Author's abstract.*)

WALTER J. HAMER: *Variation of hydrogen-ion concentration with temperature.*—Although considerable information is available on the variation of ionization constants with temperature, little is known of the variation in hydrogen-ion activity or "active acidity" with temperature. In order to learn whether the variations of "active acidity" are similar to the variations in ionization constants and whether there is a general relationship between hydrogen-ion activity and temperature, measurements were made at 5° C intervals from 0° C to 60° C of the pH values of different types of solutions by means of galvanic cells without liquid junctions, using hydrogen and silver-silver chloride electrodes. This method of measuring the acidity is independent of Soret effects and liquid junction errors, common to the usual electrometric method of measuring acidity. The solutions studied were potassium acid phthalate, sodium acid malonate-sodium malonate, sulfamic acid, boric acid-potassium hydroxide, glycine-hydrochloric acid, glycine-sodium hydroxide, hydrochloric acid, and potassium hydroxide. From the pH data obtained for these solutions, it was observed that with an increase in temperature the pH values of alkalies decrease, the pH values of strong acids increase and that the pH values of weak acids exhibit a minimum in the pH-temperature curve, the minimum occurring at different temperatures for different pH values. The degree of change in pH with temperature is smaller the closer the pH is to neutrality. It was also observed that the changes are independent of the concentration of the solution but depend slightly upon the valencies of the ions in the solutions. The difference in the variations of alkaline and acid solutions with temperature may possibly be explained by the differences in the apparent partial molal volumes of alkalies and acids and by the differences in the variation of this quantity with temperature and by the large change in the pH of water with temperature. It was also observed that the variations are different for ampholytes such as amino acids than for other types of solutions. They exhibit smaller changes in the acid range and larger changes in the alkaline range than the other types of solutions. This may be explained by the fact that the entropy of ionization of amino acids is about half that for other acids and bases and by the fact that the charges on ampholytes are widely separated, giving rise to a strong electrostatic field. (*Author's abstract.*) RAYMOND M. HANN, *Secretary.*

BOTANICAL SOCIETY

292D MEETING

The 292d regular meeting was held in the assembly hall of the Cosmos Club, November 1, 1938, President GRAVATT presiding; attendance 85. GEORGE E. HALLIDAY was elected to membership.

Notes and reviews.—WILLIAM A. DAYTON called attention to a monograph on lupines being prepared by Charles Piper Smith of Saratoga, Calif., for which subscriptions would be welcome. Hugo Glück of the University of Heidelberg has made a request for specimens of *Micranthemum nuttallii*, an aquatic plant. ROBERT COOK called attention to the fact that some patents had been issued recently on chemicals for growth of roots to the Boyce Thompson Institute.

Program.—HOWARD W. JOHNSON: *Mycological and pathological observations on Crotalaria.* *Crotalaria,* a new summer cover and green manure crop, is proving to be especially well suited to the sandy lands of the South. Two species, *C. striata* and *C. spectabilis,* already have become of agricultural importance. In plantings made to date these species have been found immune from nematodes. This fact is of great economic importance in connection with any crop throughout the South. However, diseases are already proving a factor in the growth of *Crotalaria* in the United States and in this paper attention is called to three diseases attacking the crop at Arlington Experiment Farm, Arlington, Va. These are: (1) powdery mildew (*Microsphaera diffusa*), (2) gray mold (*Botrytis cinerea*) and (3) mosaic (virus). Perithecia of the powdery mildew develop on *Crotalaria* species in both field and greenhouse at Arlington Farm. This is apparently the first report of perithecia of *Microsphaera diffusa* on this host in the Western Hemisphere and confirms earlier records of this powdery mildew on *Crotalaria* from Puerto Rico, where identification was based on the oidial stage only. The mosaic on *Crotalaria* causes dwarfing and mottling of the leaves and extreme proliferation of lateral buds (witch's brooming) on some species. The virus is readily transmissible mechanically to horsebean (*Vicia faba*), red clover (*Trifolium pratense*), crimson clover (*Trifolium incarnatum*), garden peas (*Pisum sativum*), and field pea (*Pisum arvense*). It apparently does not attack garden bean (*Phaseolus vulgaris*), soybean (*Soja max*), alfalfa (*Medicago sativa*), cowpea (*Vigna sinensis*), or *Petunia hybrida.* Host range and property studies completed to date show this virus to be similar in many respects to the known strains of pea mosaic but it differs in other respects and further work is necessary to determine whether it shall be described as a strain of pea mosaic or as a distinct entity to be known as *Crotalaria* mosaic.

E. D. MCALLISTER: *New facts in photosynthesis.* Experimental evidence was presented indicating the formation, during the actual process of photosynthesis, of a material in relatively large quantities which combines with or absorbs carbon dioxide. The experiments establishing the existence of this carbon-dioxide-combining intermediate are entirely new in type, and the intermediate bears no evident relationship with any plant material previously described as combining with carbon dioxide, being produced, as it is, only during the actual process of photosynthesis, and apparently surviving thereafter for a short time. Its presence during photosynthesis can be measured by a "pick-up" of carbon dioxide in darkness immediately following a high rate of photosynthesis. That chlorophyll is intimately related to or associated with this intermediate is suggested by a simple stoichiometry of the order of unity that is found to exist between the number of carbon dioxide molecules taken up and the total number of chlorophyll molecules present in the plant.

ALICE M. ANDERSEN, *Secretary.*

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An asterisk (*) denotes the abstract of a paper presented before the Academy or an affiliated society.

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